Eng. Lib.

SCIENTIFIC AMERICAN SUPPLEMENT. No 1902

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Published weekly by Munn & Co., Inc., at 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.

Scientific American, established 1845.
Scientific American, Supplement, Vol. LXXIII., No. 1902

NEW YORK, JUNE 15, 1912.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

Direct Current Open-type Motors Driving Hot Saws

The Rolls and Their Motor Drive, with the Controller Platform in the Background on the Left

ELECTRIC REVERSIBLE ROLLING MILL AND AUXILIARY EQUIPMENT.—[See page 376.]

"Earth Light"*

Or the Brightness, Exclusive of Star Light, of the Midnight Sky

By W. J. Humphreys

An attempt was made a few years ago by Prof. Newcomb[1] to determine the total light of all the stars. The results were far from being in accord with expectations, especially in respect to the relative brightness of the galactic and non-galactic portions of the sky.

A provisional explanation of the difficulty was made by referring the total light to two sources: direct star light, and indirect or atmospherically diffused star light; but this did not prove to be a sufficient explanation—it did not fully account for the observed phenomena. "On the whole," Newcomb says, "it seems either that my observations are wholly at fault—erroneous by an amount which I should find it difficult to account for—or we must materially modify our conclusions from the combination of star gages with the existing photometric estimates of star light."

More recently this whole subject has been investigated most carefully by Yntema,[2] who reaches the following conclusions:

1. "The light of the sky at night is composed of two parts, one reaching us directly from the stars, the other resulting from processes in the atmosphere."

2. "The latter, termed 'earth light,' is only partly due to the diffused star light. It seems probable that the rest, wholly or in part, is due to a permanent aurora."

Yntema also finds that:

a. "The general brightness of the sky, being measured by the relative brightness of the North Pole, is variable during the same night."

b. "It is varying from night to night."

c. "The observed brightness increases toward the horizon."

Yntema's observations were made at Borger, Holland, August, 1907, to May, 1908.

Still more recently, in August, 1910, Abbot[3], using an instrument similar to one of those used by Yntema—a Kapteyn sky photometer—made measurements, from the top of Mount Whitney, Cal., on two successive nights of the relative brightness of the night sky; and also of the total light per square degree in terms of a first-magnitude star.

The results obtained by Abbot on Mount Whitney at an elevation of 4,420 meters agree in general with those of Yntema, which were obtained practically at sea level. They are, however, smaller in the ratio of 7 to 10, approximately.

The phenomenon of "earth light" seems therefore to be a thing of the high atmosphere, and to be a very general occurrence both as to time and place. Its variability and its increase with zenith distance seem to preclude attributing it wholly to any celestial or combination of celestial sources, such as diffused star light, reflection and scattering of sun light by meteoric particles and dust, or anything in the nature of the zodiacal light or the *Gegenschein*. On the other hand, Yntema's suggestion that it may be due wholly or in part to a permanent aurora—whatever the cause of this in turn—appears very plausible, and especially so since the green "auroral line," λ 5770, may be seen on almost any dark clear night in any part of the sky.[4] That it is a phenomenon essentially of the upper atmosphere, auroral or what not, seems probable.

If it is wholly of auroral origin it would appear that it should, in general, be brightest in those regions where ordinary auroras are brightest, and faintest in equatorial regions. This question, however, is not definitely answerable from the published data.

Apart from the permanent aurora there is one other source of light—perhaps to some extent of the permanent aurora itself—the possible effect of which it is the specific purpose of this paper to consider.

The source in question is the continual bombardment of the outer atmosphere by material of meteoric origin; including under this term all particles picked up by the earth in its orbital motion, whether of cosmical, solar, or any other origin. So far as this produces light at all it will be through a considerable depth of the outer rare atmosphere, and hence, in general, must appear somewhat brighter with increase of zenith distance. It should also be nearly independent of any attainable altitude, and therefore, is in accord with observations.

For simplicity of numerical calculations it will be assumed that the "earth light" is of both constant and uniform intensity—the same over all parts of the sky, invariable, and continuous. Obviously these conditions could be met, so far as intensity of light reaching an observer at the surface of the earth is concerned, by a properly illuminated white-mat screen concentric with and some distance above the surface of the earth.

Further, the total amount of light given off by a self-luminous layer of the atmosphere, since it must radiate equally both outward and inward, would be *twice* that diffusely reflected by an equally bright white-mat surface of the same area. Now the amount of "earth light" per square degree is found by Yntema to average, roughly, one-tenth the light from a star of the first magnitude.

This furnishes a means of also comparing the brightness of "earth light" with that of the moon, as follows. When full the moon is equal to a star of —11.77 magnitude, or the equivalent of 120,000 stars of the first magnitude, and covers about 0.2 of a square degree. Hence the full moon is 6×10^6 times brighter than the sky would be if illuminated by "earth light" alone.

It is now possible, and also essential to certain energy calculations to follow, to measure the brightness of "earth light" in terms of meter candles. The brightness of the full moon is the same as that of a white-mat surface illuminated by a 1,200 candle-power light at one meter's distance,[5] or, in symbols:

Brightness of full moon = 1,200 m.c. (meter candles). Therefore

Brightness of "earth light" $=2\times10^{-4}$ m.c.

Now the average velocity of meteoric matter, as it enters the atmosphere, seems to be about the "parabolic velocity" due to the sun's attraction at the earth's distance, or roughly 42 kilometers per second. Also the number of such particles appears rapidly to increase with decrease of size, and presumably the number of those that are far too small to produce visible streaks is vastly greater than the number of all combined that are large enough to be individually seen.

Further, any object, however small, entering the atmosphere with so great a velocity is in the condition of being acted upon by a flame of very great temperature—a temperature quite independent of the density of the atmosphere, assuming it of constant composition. Even if the atmosphere were all hydrogen, the entrance of an object into it with the velocity of 42 kilometers per second would produce the same effect as submitting it to equally dense hydrogen at the temperature (computed) of 142,000 deg. Cent. If the atmosphere were oxygen the computed temperature would be 2,266,000 deg. Cent. In either case both the velocity and resulting temperature (computed) are far beyond anything of the kind dealt with in the laboratory, except in the case of electrons, α particles and the like; and quite sufficient, as both theory[6] and experiment[7] indicate, to produce abundant ionization.

This then may be, at least in part, the source of the so-called permanent aurora—the origin of the necessary ionization, assuming the green auroral line to be due to electrical discharges.

It is well known that the amount of light that a solid body gives off increases very rapidly with increase of temperature. Hence meteors may be intrinsically brighter than any known artificial source. At any rate they have the general appearance of stars in rapid motion as their popular name, "shooting stars," indicates. It will therefore be assumed that the distribution of the total energy between heat and light is the same for meteors as it is for the sun. But the solar constant is about 1.92 calories per square centimeter per minute, and this gives, on the surface of the earth, when the sun is overhead, an illumination of 10^5 meter candles.[8]

As seen above, the brightness of "earth light" is 2×10^{-4} meter candles, and therefore normal zenith sunshine is 5×10^8 times brighter than "earth light," and delivers 25×10^7 times as much energy per square centimeter as is given out from both sides combined per square centimeter of the effective self-luminous shell or surface to which the "earth light" is due.

Hence the total energy used, according to the above assumptions in producing the "earth light" is

$$4\pi R^2 \times \frac{1.92}{25\times10^7} \text{ calories per minute,}$$

in which R is the radius of the earth in centimeters, or

$$27\times10^{15} \text{ ergs per second, roughly.}$$

Assuming this energy to be furnished by M grams of matter moving with the velocity of 42 kilometers per second we have,

$$\tfrac{1}{2}MV^2 = 27\times10^{15}$$

or

$$M = 3\times10^3\text{, roughly.}$$

While this is nearly 300 times the estimated amount of material in visible meteors, it is less than three times the amount Young[9] assumes as allowable, and, so far as there is any present means of knowing, may be even less than the actual amount of meteoric dust caught up per second by the earth's atmosphere. Indeed it is relatively so small that it would take something like two hundred million years for it to increase the radius of the earth a single centimeter!

But, as stated above, probably a good deal of ionization is produced by the swiftly moving meteoric dust. If such ionization is produced it follows that the radiations thus excited, like those due to ordinary electric discharges in gases, may be largely concentrated in the visible region of the spectrum. Hence the above calculated amount of meteoric matter, 3 kilogrammes per second, may be more than is actually necessary to generate by the two processes combined, high temperature and electrical discharges, the observed amount of "earth light." In this connection it should be remembered that Yntema's values are distinctly larger than those obtained by most others[10] who have worked on this subject, and that therefore the computed amount of energy and meteoric material may be excessive, or, at least, much above the average.

If "earth light" is wholly due, directly or indirectly, or even measurably due to the bombardment of the upper atmosphere by meteoric dust, then it should be brighter, presumably, during the later hours of the night, when the sky overhead is more nearly on the forward side of the earth in its orbital motion. Unfortunately, however, the data at hand are not sufficient for the application of this check to the above theory as to the origin of "earth light." Many more observations are needed for the complete understanding of this faint, but apparently continuous, light; and the above roughly quantitative examination of one probable source of at least some of the light is offered in the hope that it may help to narrow the problem, and indicate one or two points to be examined.

* Reproduced from the *Astrophysical Journal*.

[1] *Astrophysical Journal*, 14, 297, 1901.

[2] "On the Brightness of the Sky and the Total Amount of Starlight." Groningen: Gebroeders Hoitsema, 1909.

[3] "Annual Report Smithsonian Institution," 1911, p. 64.

[4] W. W. Campbell, *Astrophysical Journal*, 2, 162, 1895.

[5] "Circular of the Bureau of Standards," No. 28, p. 7, 1911.

[6] P. G. Nutting, *Astrophysical Journal*, 21, 400, 1905.

[7] A. Wehnelt, *Phys. Zeitschr.*, 9, 134, 1908; O. W. Richardson, *Phil. Trans.*, A, 201, 497, 1903; and others.

[8] "Circular of the Bureau of Standards," No. 28, 7, 1911.

[9] "General Astronomy," p. 475.

[10] C. Fabry, *Astrophysical Journal*, 31, 394, 1910.

The Pressure of a Blow—I.*

And the Impact of Projectiles on Armor Plate

By Prof. Bertram Hopkinson, M.A. F.R.S., M.Inst.C.E.

The scientific analysis of a blow requires first the determination of the actual pressures or forces set up between the colliding bodies, and second an investigation of the distribution of these pressures and of their physical effects. The pressure produced by a blow does not differ in kind from that produced by any other agency, such as an hydraulic press, but it differs in degree because of its great intensity and of its extremely short duration.

The first part of the problem, that is the calculation of the pressure in tons or pounds, is based on the familiar principles of mechanics which were first precisely stated in Newton's laws of motion. The cause of the pressure is the rapid change of motion of the colliding bodies which occurs when they come into contact, and, according to Newton's second law, the force is simply proportional to the rate at which this change is effected. The rate of change may be measured in terms of energy and distance, or in terms of momentun and time. Thus, a hammer head, moving at a rate of 16 feet per second, and weighing 1 pound, possesses 4 foot-pounds of energy,

* Paper read before the Royal Institution of Great Britain.

because its velocity could have been acquired by falling freely through 4 feet. If it strikes a nail and drives it one-eighth of an inch, the energy which was generated by the weight of 1 pound acting through 4 feet is destroyed in 1/400 part of that distance, and the force necessary to effect this change of motion is 400 times as great, say 400 pounds. The same effect would be produced by a 4-pound hammer striking with the velocity which would be acquired by falling through 1 foot, namely, 8 feet per second. Regarding the same instance from the point of view of momentum, the 1-pound hammer would take half a second to fall 4 feet, and the quantity of motion or "momentum," reckoned as the product of the force acting into the time required to generate it, would be one-half of a pound-second unit. While driving the nail in, the hammer covers a distance of 1/8 inch with a velocity which starts at 16 feet per second and drops to zero. To cover the distance of 1/8 inch with the average velocity of 8 feet per second takes 1/800 of a second, which is 1/400 of the time (½ second), which it takes the weight of the hammerhead (a force of 1 pound) to generate its motion. Thus the pressure required for the rapid stoppage is as before, 400 pounds.

We may take another instance essentially similar to the hammer and nail, but differing greatly as regards scale. A 14-inch armor-piercing shell weighs about 1,400 pounds, and when moving at 1,800 feet per second possesses about 31,000 foot-tons of energy, or about 15,000,000 times as much as our hammer head. Such a shell would just pierce a plate of wrought iron 2½ feet thick, and the average force which must be exerted to pull it up in that distance, which is of course the pressure which it exerts on the plate, is 30,000 divided by 2½, or about 12,000 tons. This is equivalent to some 80 tons on the square inch.

When a hammer strikes a nail, the force acting during the blow is practically constant, and the average value obtained as above by dividing the energy by the distance moved, or the momentum by the time taken, is equal to the actual force exerted throughout the impact. In many cases, however, this force is not constant, and it is then necessary to divide the course of the impact into short intervals either of space or of time, calculate the change of energy or momentum in each, and add the result. A familiar instance is that of two billiard balls. We may suppose one ball to strike the other full with a velocity of 16 feet per second, which corresponds to a fairly hard stroke. It simplifies the consideration of the problem, if instead of one ball moving and the other at rest we suppose them to be travelling in opposite directions with equal velocities of 8 feet per second. At the instant when the balls first touch there is no pressure between them, but as they continue to approach, each flattens the other at the point of contact. The balls no longer touch at a point, but over a circular area which rapidly increases in diameter. Corresponding to any given amount of flattening or distance of approach, there is of course a definite pressure which might be measured by actually squeezing the balls together under known forces and measuring the corresponding amount of approach. Or the relation between pressure and distance could be calculated as was done by Hertz. The results are shown in the curve (Fig. 1), and the area of the curve connecting pressure and distance up to any point gives the number of foot-pounds of energy destroyed. When this is just equal to the original energy of the balls they will have been reduced to rest, and in the case supposed, the distance of approach is then 14/1,000 of an inch, and the total pressure between them 1,300 pounds. This pressure is distributed over the circle of contact which is 1/6 of an inch in diameter, and the average intensity of the pressure is 27 tons per square inch. The distribution, however, is not uniform, the pressure at the center being 1½ times the average. The balls are then like compressed springs, their original energy of motion having been completely transformed into strain energy in their substance. The reason of the high intensity of pressure developed is that this strain energy is concentrated into a very small volume of ivory near to the point of contact. The balls then begin to separate, and the whole process of compression is gone through in reverse order, the

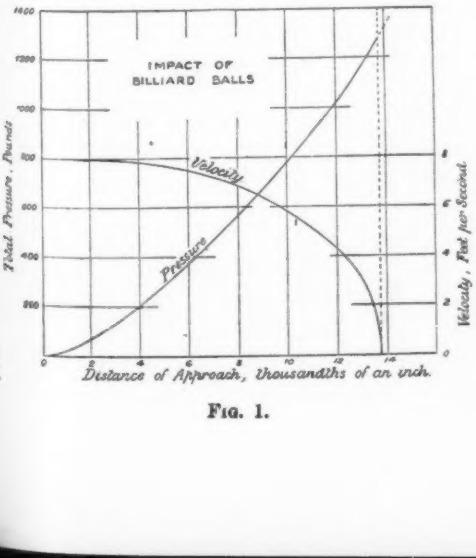


Fig. 1.

strain energy being transformed back into energy of motion by the pressure. Finally the balls rebound unstrained, with nearly the velocity with which they approached.

If for the ivory balls we substituted hollow balls of steel having the same mass, the pressure produced by the blow would be greater, because the steel is much more rigid than ivory and gives less under a given force. Thus the distance of approach is less, the circle of contact smaller, and the maximum intensity of pressure much greater. It reaches 280 tons per square inch averaged over the surface of contact. Such a pressure could only be sustained without permanent effect by a very hard steel. Ordinary mild steel would begin to flow when the pressure passed about 100 tons, a permanent flat would be left by the blow, and the balls would rebound with less velocity than that of approach. The theory whose results I have given does not, of course, apply to such a case, as it depends on the assumption of perfect elasticity.

It is rather remarkable that materials can sustain without injury such large pressures as are produced by these blows. Mild steel balls are not crushed perceptibly till the pressure reaches 100 tons per square inch; yet a short column of the same steel would be crushed by a pressure of 30 tons per square inch. One reason is the extremely short duration of the pressure—it has no time to produce much effect. The other is the fact that in the blow it is accompanied by large lateral pressures exerted by the metal surrounding the area of contact. Pressure equal in all directions, such as is exerted by the water at the bottom of a deep ocean, produces generally no permanent effect on solids or liquids. To produce breakage or permanent deformation there must be difference of pressure in different directions, and the most important if not the only factor determining whether such breakage or deformation shall occur is the amount of the difference. If, for example, our column of mild steel, which in the absence of lateral support begins to crush at 30 tons, were surrounded by a jacket exerting a radial pressure of 30 tons, it is probable that the end pressure might be increased to 60 tons without any movement occurring. In the impact of balls the metal surrounding the point of contact by resisting the lateral expansion of the compressed part, sets up radial pressure of this kind. It can be shown, in fact, that the lateral pressure at the center of the circle of contact corresponding to a maximum normal pressure of 100 tons per square inch is 75 tons per square inch, leaving 25 tons effective for producing deformation or breakage. The greatest difference of pressures, however, is not at the center of the circle of contact but at points near the circumference of that circle. Thus, as was found by Hertz, fracture commences by the formation of a circular crack of small radius surrounding the point of first contact.

These calculations of pressure are based on theory, and it may be asked what direct experimental evidence we have that the theory is correct. It is not, of course, possible actually to measure the pressures over the minute circle of contact between the balls, nor is it possible accurately to measure the amount of the flattening. We can, however, pursue the calculation a little further, and determine the time during which the balls are in contact from the moment when they first touch to the moment at which they separate on the rebound. In the case of billiard balls moving with a relative velocity of 16 feet per second, this time is 1/4,000 of a second. A precisely similar calculation can be made for balls of steel or other metal, and it is not difficult to measure in the laboratory the time during which such balls remain in contact. The method is of considerable use in connection with impact problems, and it consists in making the two balls, by their contact, close a galvanometer circuit in which there is also a battery and resistance. A certain quantity of electricity, which is simply proportional to the time of contact, then passes through the galvanometer and produces a proportionate deflection in it. It has been found that the time of contact measured in this way for steel balls is exactly that predicted by theory, and it may be inferred that the theory is correct in all its details, and that the pressure calculated by its aid corresponds with the facts. This method was first used by Pouillet in 1845, and has recently been brought to great perfection by Mr. J. E. Sears,[1] who showed, among other things, that the relation between pressure and deformation of steel is almost exactly the same when the pressure is applied for an excessively short time, as in the case of impact, as it is when applied steadily, as in a testing machine. The assumption that this is the case lies of course at the root of the calculations, and its verification was therefore a matter of considerable importance.

When one billiard ball strikes another the effect of the blow is practically instantaneously transmitted to every portion of the colliding balls, or, to speak more precisely, the time taken to transmit the pressure is short compared with the total time of contact. Except for the minute relative displacement near the point of contact the balls move as a whole, every part having the same velocity at each instant of time and coming to rest at the same moment. In many cases of impact, however, and in those possessing the most interest from a practical point of view, this is by no means the case. We may consider, for instance, the impact of an elongated lead rifle bullet against a hard steel plate. Under the enormous pressures developed lead flows almost like water, and in the absence of lateral support it is as little capable of transmitting those pressures. Thus, when the nose of the bullet strikes, the metal thus brought into contact with the plate immediately flows out laterally, its forward motion being destroyed, but the hind parts of the bullet know nothing of what has happened to the nose because the pressure cannot be transmitted to them, and they continue to travel on with the original velocity until they in turn come up to the plate and have their momentum destroyed. The process of stopping the bullet is complete when its tail reaches the plate, and the time required is simply that taken by the bullet to travel its own length. Thus a Lee-Metford bullet is 1¼ inch in length, or, say, 1/10 of a foot, and if moving at 1,800 feet per second, which is about the velocity given with a rifle, it would be stopped in 1/18,000 of a second. The bullet weighs approximately 0.03 pound, and possesses with this velocity about 1.7 pound second units of momentum. The force required to destroy this in 1/18,000 of a second is 18,000 multiplied by 1.7 pound, or, say, 15 tons. This acts over the sectional area of the bullet, which is 1/14 of a square inch, giving a pressure of about 210 tons per square inch. This is the average pressure throughout the impact, but the pressure is probably nearly constant. It is to be noted that the pressure per square inch depends only upon the velocity (varying as its square), and not upon the length or diameter of the bullet. Increase in diameter only alters the area over which the pressure is applied, and increase in length the time during which it is applied.

To be continued.

[1] Camb. Phil. Soc. Procs., vol. xiv., p. 257.

The Sense of Orientation in the Ant

It has been a matter for considerable discussion just how ants find their way and know their bearings in their complicated and extensive wanderings over the surface of the soil. It can hardly be said that any consensus of opinion has been reached as to the mechanism by which the ant, after leaving the nest in search of food, finds its way back to the point from which it started. The problem is somewhat complicated by the fact that an ant does not return by the same track as it went out. Some interesting and rather remarkable observations have recently been made by Mr. Cornetz, in Algeria, and are noted in a recent issue of *La Nature*.

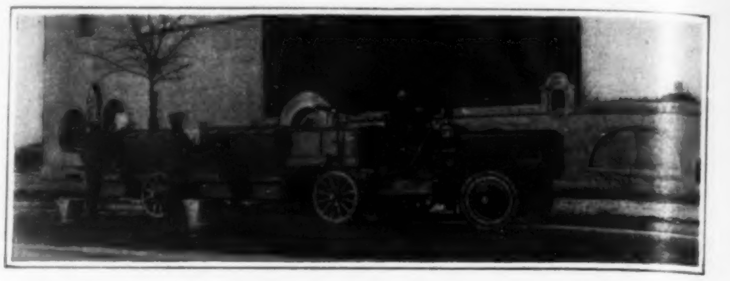
According to this observer, the ant, in its outward journey, proceeds throughout in the direction initially chosen; on its return the insect places its body at the same angle, and walks in the opposite direction. The body of the ant would therefore act as a kind of compass needle.

It must be remarked that this observation applies in the first instance to a single ant proceeding on its journey alone, for, as Mr. Cornetz rightly argues, the proper study of the phenomenon must begin with the consideration of as simple as possible a case.

The author specially warns his reader that an opinion should not be formed except when a complete journey has been observed. No conclusions can be drawn from isolated portions of the ant's movements. An individual ant leaving the nest must be followed up from the time of its departure until it returns to the ant hill. The entire journey must be plotted and its course should be recorded as nearly as possible in exact copy of nature.

If an ant is caught at the nest and transported to a point some yards distant, the insect is quite incapable of finding its way back. It runs around on the ground until it accidentally comes across the entrance to the burrow. The case is quite different if an ant is allowed to find its way to a distance unmolested. On leaving the nest it places itself in a certain direction and holds the same, no matter what obstacles it may meet with *en route*, and no matter what side tracks it may occasionally strike in order to seize some article of food or of structural value for its nest. Finally the insect reverses its motion and returns, parallel to the outward journey. The return is effected directly, rapidly and without hesitation, even if the ground covered has been swept in order to change its relief. The return is obviously determined completely by the outward trip, and an ant which has left its nest on a voyage of exploration finds its way back just because it has made the outward journey. If an ant is caught at the moment it returns to the nest and is put down at the opposite side of the opening, it first of all arranges its axis in the direction originally adopted, and then runs off rapidly away from the nest. Incidentally, it should be stated that on its return the ant does not usually strike the nest exactly, but comes to within a few inches and sometimes a few feet of it. It then stops, and, whereas, until that moment, its progress was rapid and unhesitating, the insect now runs around in a seemingly aimless fashion. It is from this moment on that sight, touch and smell are called to assistance by the insect.

The New Refuse Collecting Wagon, Equipped for Horse Traction.



Transferring Refuse to the Collecting Wagon. A Dustless Process.

Refuse Disposal at Fürth, Germany

Up-to-date Methods in City Hygiene

By Dr. Alfred Gradenwitz

Until recently the methods employed in dealing with domestic garbage and refuse in the Bavarian city of Fürth were decidedly primitive and unsatisfactory. A radical change has since been made, and the new equipment for the collection and disposal of offal is well worth noting. In the first place, it was decided that the city itself should take matters in hand instead of employing the services of a private enterprise. In view of the fact that special circumstances are apt to arise, as for instance at the time of an epidemic, which urgently require immediate and adequate attention, this arrangement seems decidedly the most desirable, for it renders the community independent of the whims and shortcomings of a private commercial enterprise, for whom the welfare of the community may not always be the first consideration.

Each house is provided with one or more galvanized sheet-iron bins or pails, of "coal shuttle" shape, as seen in one of our illustrations. These bins are all of one standard size, a little over one cubic foot in capacity, and are tightly closed by a sliding cover. They are sold to householders for the sum of 3.75 marks (a little less than a dollar) each, which in 70 per cent of all cases was paid in cash. In the remaining 30 per cent of purchases an arrangement has been made for the payment to be made in twenty-five monthly installments.

The collecting wagons are so built that they can be drawn either by horse or by an electric tractor, and as a rule the latter means is employed. The wagon has four removable segments on each side, which in the regular course of events are filled in about an hour, the bins fitting against the top of the wagon in such manner that all raising of dust in emptying the bins is prevented; the wagon is then taken at a rapid pace to the refuse destructor plant. Here an electric traveling crane lifts the body from the wagon and transfers it to the charging truck of the destructor furnace. The contents are dumped into the furnace, the draught of the chimney keeping the dust from spreading out into the air; the refuse falls directly upon the furnace grate, while the emptied wagon-body is removed by the traveling crane and put back on the cart.

The refuse introduced into the furnace takes fire immediately on coming in contact with the incandescent walls of the combustion compartments and the slag left on the grate. This consists of two parts, viz., a main and a preliminary grate. The air for combustion is supplied to the grate by turbo-blowers, through a set of conveniently distributed nozzles. The refuse thus burns on the main grate at the rate of about 35 cubic feet every 15 to 30 minutes, being converted into a solid lump of slag, which is then transferred by means of hooks to the preliminary grate, where it remains until the next charge (i. e., 15 to 30 minutes). Owing to this prolonged stay of the slag in the furnace, any coke and coal particles remaining in the slag are completely burnt, while the heat of the slag is usefully employed in the furnace itself. The surplus air from the preliminary grate serves to actuate the combustion of any flue gases produced on the main grate.

Refuse Wagon of the Old Service.

The Charging Platform of the Refuse Destructor Furnace.

The flue gases coming from the combustion compartments first enter a mixing compartment where they are intimately mixed while depositing the coarser flue dust. As the temperature rises to 1,200 or 1,400 deg. Cent. in the furnace, the complete combustion of all organic matter is insured. The flue gases then proceed to a boiler where they serve to raise the steam required for the gas works, and then escape through a stack 165 feet high.

The steam produced in the boilers at a pressure of 10 atmospheres is either used directly for general purposes or is converted by steam-operated generating sets into electrical energy supplied to the mains of the power-house.

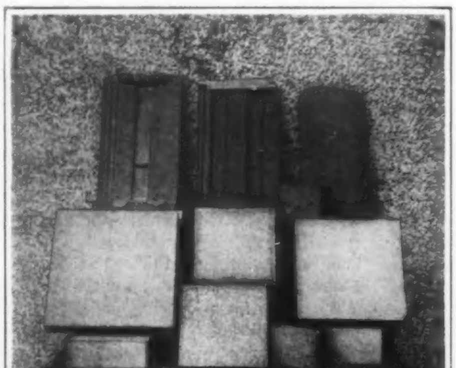
The slag is discharged by machinery which allows the most bulky pieces to be dealt with automatically and in a very short time. The slag is taken to a water tower to be slaked and is finally discharged.

According to the opinion of many experts, the slag constitutes a valuable material for concrete mixing, in place of the gravel generally used. It is also found to be most suitable for the manufacture of slabs, pavements, etc.

The output of the destructor plant is about 2,200 to 2,600 pounds of refuse per hour for each furnace compartment. One day's waste material of the whole city is thus burnt in 12 to 16 hours, and owing to the perfect condition of combustion, each pound of refuse produces one pound of steam at a pressure of 10 atmospheres.

Influence of Time and Season Upon the Frequency of Accidents.—German accident statistics bring out some interesting facts relating to the influence of the time of day and the season of the year on the frequency of accidents. So far as the season of the year is concerned, it cannot be said that there is any marked difference from month to month, although a slight maximum was observed in October, with 9.39 per cent of the total number of accidents. On the other hand, the days of the week show a very marked difference as regards the frequency of accidents. The greatest number occur on Mondays, which, it is to be feared, must be largely attributed to the abuse of alcohol on Sunday. The number goes down greatly on Tuesdays, and reaches the minimum on Wednesday, if Sunday is excepted, which, of course, does not correspond to normal working conditions. From Thursday on the number of accidents increase again, and on Saturday their number is about intermediate between that on Monday and Tuesday.—*Prometheus.*

Some of the Garbage Receptacles Typical of the Old Regime.



Slabs and Plates. By-Products from the Refuse Destructor Furnace.

The New Hygienic Refuse Pail.

Engine Foundations*

Their Function to Hold the Engine and to Absorb Vibrations

By R. B. Dale

Engine foundations perform two functions; they hold the engine bed rigidly in place and they absorb vibrations. The foundation must, therefore, be heavy and bulky and it must have a substantial and firm bearing in the earth. Concrete is by far the most available and best suited material for this purpose. It is not only a comparatively inexpensive material but it is also exceedingly convenient to handle and to mold into the necessary form. Moreover, with intelligent supervision, the foundation may be built without the use of skilled labor. However, sufficient time must be allowed for the concrete to set before a load is placed on the foundation.

The engine base is held to the foundation by means of anchor bolts. These are mild-steel rods several feet long with a square nut and anchor plate at one end and a hexagon nut at the other. The foundation is usually built and the anchor bolts set in the locations indicated for them on the engine builder's setting plans before the engine has been shipped so that the foundation may be ready to receive it when it arrives. The anchor bolts are hung from a template which is securely fastened to the top of the forms for the concrete, and the anchor plate is completely buried in the concrete. A small wooden box, tapering from the lower end to the upper end, is made to surround the anchor bolt; this allows for a slight adjustment of the bolt so that it will fit into the cored holes provided for it in the engine bed. This precaution is necessary because it is almost impossible and, in any case, too expensive, to set them so that an accurate fit is obtained.

When the engine arrives and after the concrete has properly set, the engine is moved to its foundation where it is set into position. Small iron wedges are driven under the edge of the engine bed until the engine is level, thus leaving a space of ½ inch or more between the engine base and the top of the concrete. The hexagon nuts on the upper ends of the bolts are then tightened up, after which a cement grout is run under the engine base and allowed to set. When the grout has set the wedges are removed and the nuts on the anchor bolts are again tightened as much as possible.

In order that the foundation may perform to the fullest extent its function as an absorber of vibrations, the vertical hole through which the anchor bolt passes is not filled with grout. This allows the bolt to stretch or elongate throughout its entire length whenever subjected to shock. It may be said to act somewhat in the manner of a spring. If the anchor plate is of ample area, no advantage in holding-down force is obtained by grouting the bolt for the whole of its length as the bond between the steel and the concrete is comparatively slight in effect. Any lateral movement of the engine on the foundation is prevented by the force of friction which exists between the engine bed and the top of the foundation. The greater the initial tension in the bolts, the greater is this resisting force. If a slight movement should take place this resisting force would increase enormously because the tension in the bolts would increase as they are stretched to accommodate themselves to the new position. Shearing strains which are liable to occur in the bolt between the top of the foundation and the engine bed, if it is completely bedded in the grout, are also prevented.

It is sometimes necessary to change an old foundation to accommodate a new arrangement, such as the compounding of low- and high-pressure steam cylinders, to increase the power of the engine. Whenever it is necessary to set an anchor bolt in an old foundation, the difficulty may be met in one of two ways. In the first method a hole is drilled in the concrete slightly larger in diameter than the bolt to be used and to the proper depth. A bolt is then prepared by cutting a slot in one end lengthwise of the bolt and about six or eight inches long. This slot is then fitted with a wedge of hardened steel held in place by a pin of soft copper or other soft metal. The bolt is lowered into the hole and struck several hard blows on the upper end with a heavy hammer. This shears the soft metal pin and drives the wedge into the slot, thus enlarging the diameter of the bolt at the lower end. The bolt is then grouted into the hole and the nut is tightened to complete the work.

In the second method a hole is drilled for the bolt as before. A second hole is then drilled laterally through the side of the masonry to meet the first hole and this is enlarged sufficiently to take the standard anchor plate. The work is completed in the customary manner, precautions being taken to grout the anchor plate to a firm bearing in the old concrete. The first method is cheap and simple, although there is no certainty as to what happens in the bottom of the hole. It also has the advantages of the grouted bolt previously mentioned. The second method, while it is more troublesome and expensive, is the more reliable and should be used in preference to the first.

The reciprocating engine, since the tendency to produce vibration is greater than in the case of the steam turbine, requires a comparatively heavy foundation. In some cases and in peculiar locations this advantage of the turbine may be so great that the choice of equipment is strongly influenced in its favor. The heavy foundation is expensive to build and, in the case of large units, the cost of the foundation forms a large percentage of the total expenditure of the installation.

* Reprinted from *Power*.

Turpentine from Dead and Down Timber

Recovering Values from Seemingly Waste Material

Less than ten years ago certain far-sighted turpentine operators in the South began to take thought of utilizing the dead "light wood" in the pine forests for purposes of getting turpentine, which was then rapidly advancing in price. There are at present vast quantities of pine logs and tall stumps left as a result of careless lumbering in the past. This material is rich in turpentine and a cord of dead pine wood can be made to yield from 12 to 16 gallons of the spirits. The time is short until the bulk of the available dead pine wood in the southern pineries will be utilized for this and other purposes. The State of Florida, to say nothing of the other yellow pine producing states, is annually losing many thousands of dollars from the waste of this dead and down timber. There are millions of cubic feet of standing pine timber unfit for saw logs, left in cut-over land. There are millions of cubic feet of the richest light wood in the form of stumps, which can be utilized very profitably. The conservationists found a way to use this wood that is now wasting, for the purpose of making the best grades of turpentine and alcohol. This is now being done on a large scale with promises of a still further growth. A number of plants have already been built in Florida and Georgia for the purpose of converting the dead and down light wood, stumps and mill waste, etc., into turpentine and other by-products.

The problem of determining whether it is cheaper to gather the dead wood and the stumps for the turpentine they contain, or to tap live thrifty trees and distill the resin, has been satisfactorily worked out. There seems to be little doubt as to the answer when the small cost of the dead pine wood is considered. It is estimated that there are more than a million cords of dead wood in the State of Florida alone. None of it is valuable enough to pay the cost of transportation for purposes other than that of dry distillation. A conservative estimate of the

Trees Killed by Wind, Insects and Fire in Florida.

Trees Killed by Boxing and Fire in Washington County, Florida.

actual amount of turpentine which could be produced from this material would place the amount at not less than 12 million gallons. This is a surprising figure when it is remembered that it represents an amount more than one half of the present value of the annual export of naval stores.

Even this enormous amount of dead wood can not last for all time, but until the time when the bulk of it is used up a great many young trees will perhaps be spared by the turpentine operators who chip trees as small as 4 or 5 inches in diameter breast high. The result of this economic use of the dead and down timber is, therefore, two fold; first, it means the utilization of a forest product which has hitherto been considered valueless; and second, it saves a large proportion of the young standing timber from being chipped for the resin, which is a still greater step in advance, for the very young trees are now being chipped for the turpentine irrespective of their future value either for turpentine or for lumber. This is not the only saving. Turpentining alone does not kill the trees, but it prepares the way for severe fires which are sure to pass annually through every pine district of the South. The scarified surfaces often catch fire, which almost invariably kills the trees. This not only ends the resin flow, but usually the trees will fall to the ground and increase the fire danger still more the following year. If the chipping of young and immature trees in general would cease for a period of years the turpentine operators who extract turpentine from dead wood could gain sufficiently to expand and get the product upon the market. Capital would be put into the plants and the work could be done on a monstrous scale. It has been demonstrated that it is cheaper to produce a gallon of turpentine by utilizing the dead and down timber which has otherwise no value, than by tapping the valuable live trees.

Recent Cancer Research—II*

And Modern Views Regarding the Nature of the Disease

By W. R. MacDermott, M.B.

(Concluded from Supplement No. 1901, page 359)

In general, the cancer cell is associated with foci of chronic irritation, and with congenital tumors and misplacements of tissue. It may be looked on as a normal cell diseased, because misplaced in an abnormal site, or as such a cell in a site which has become abnormal for it. In addition to rejecting its embryonic nature scientific research discredits the idea that it is a foreign or parasitic cell, and also that which takes it as a specific cell abnormal in nature *ab initio*. Its true nature may be arrived at by considering the conditions under which the fixed tissue cells resume proliferation, and their mode in doing so; which is not at all by reversion to the embryonic form. Wherever a breach of continuity of normal tissue occurs, as in a wound, ulcer, or broken bone, the adjoining cells proliferate, resuming a power inherent in them, and close the breach by a tissue of new cells. Practically all cells have this power, and exert it on occasion, following a normal routine in doing so, liable, as every such routine is, to departure from the normal. If the case is one of a compound fracture, there is breach of continuity of bone, muscle, connective tissue, and skin, and each of these tissues repairs itself by its own proper cells, there is no true reversion to the generalized embryonic form; it is to frame an unnecessary hypothesis to suppose that embryonic cells exist in or enter the process. But the newly-formed cells, constituting granulation tissue or granulomata, as we will call it, are unlike the parent cells, but become by transformation similar, though never precisely similar in each case; the difference between a cicatrix and the natural skin is permanent and sufficiently obvious, and cicatricial tissue or granulomata is far more prone to pathological change than the original natural tissue. Wherever we have cancer on however so minute a scale, we have an inclusion representing, no matter what its origin may be, a breach of continuity. The inclusion, like other items of cellular structure, may remain for an indefinite time in the resting state. When, however, it passes for any reason from that state, we have what is equivalent to a wound, and, therefore, the effort to heal it by granulation tissue. But the virtual wound may be a complex one; the cells of the inclusion, and of the including area, may both proliferate, developing two kinds of granulomata, between which a struggle for existence ensues. The cells of the inclusion, remaining passive, or relatively so, the cell mass is absorbed, cast out, or reduced to minute dimensions. Some tumors, benign and cancerous, are got rid of in this way, by proliferation, not in themselves, but in their tissue environment. The case, however, occurs where proliferation is started in the inclusion concurrently, or even alone, which gives rise to tumors of great size, tolerated, sometimes, by their environment.

The clearest instance of what commonly happens is when cancer cells are transplanted, the most favorable case for such transfer being the inoculation of, say, a mouse suffering from spontaneous cancer, with cells from its own tumor. There are two common kinds of cancer, carcinoma characterized by squamous or scale-like cells, and sarcoma, in which a spindle-shaped cell is common; in both cases, however, the cells in general are polymorphous, or have many forms. The transplanted graft, being distinctly carcinoma, is composed of connective tissue or stroma, and carcinomatous cells, and the graft, when it takes, grows in the first instance as a carcinoma. It is, however, what we call an inclusion, and both its cells and those of the including site, proliferate and form in common granulation tissue or granulomata. What follows eventually is that the stroma or connective tissue of the graft degenerates, and is replaced by the stroma of the site, and as this happens the carcinomatous cells disappear. If the thing ended here the cancer would be cured, but, as on the larger scale, in the cell world one evil begets other and often worse evils. For some as yet unexplained reason, the connective tissue of the site, as it comes to replace that of the graft develops in itself sarcomatous cells which, co-existing at first with the carcinomatous, come in the end to replace them. There is here no transformation of the carcinomatous into the sarcomatous variety; the transformation is of the cells of the site into the latter. Disregarding the influence of the carcinomatous cells on the tissue replacing their proper stroma, which is a very obscure matter, the *prima facie* inference is that the sarcomatous cell originates immediately in and from the granulation tissue of the site, that the graft, the original seat of the cancer does not give it. It would appear that the carcinomatous was a granulating cell of one tissue, the sarcomatous of another. In point of fact, carcinoma and sarcoma arise quite independently of each other, though found mixed in the same tumor frequently. The inference in general would be that skin, connective tissue, bone cartilage, each according to its form of proliferation or granulation generated a specific cancer cell of its own. The inference, however, is a misinterpretation of a fact essentially general, not particular in form. Following the normal routine of repair, the granulation tissue in connection with, say, bone, gives bone, but conceiving the routine departed from, it may give some other kind of tissue. The granulation process does not give bone immediately, but by transformation effected normally by several steps, arrest of and retrogression from which are known to occur. No matter what the tissue is which is under repair, the primary proliferating cell formation is very much alike, and in general the formation may stop short, go too far, or give by aberrant or arrested transformation abnormal tissue.

The study of sarcoma, which is the most generalized form of cancer, shows us the cell reproducing in proliferation, not one, but almost every kind of tissue, or attempting to do so. We find in a sarcoma bits of bone, cartilage, groups of blood cells, or hæmatomata, and so on. What we will not find in it is a cell which we can call in particular the cancer cell; its spindle-shaped cell is one found occurring commonly in ordinary wound-healing tissue and granulomata. From its very nature there is no cell in particular malignant in it; all its cells alike are normal cells, which have deviated from the normal type in tissue formation, some more, some less, some as a mere fact of association, being in bad and loose company. As a statement admitting exceptional cases, it may be said that cancer is a disease common for all cells, varying according to the environmental conditions which they happen to be under. Keeping to the cell itself the disease arises through its proliferating, and, in doing so, producing at random virtually every kind of cell formation out of place, and not under any normal time-rate. The essential condition for this is limitation to the granulation cell formation implied in a wound, an abnormal inclusion or other breach of continuity, however minute. The granulation formation following a normal routine repairs the breach but, both while it exists, and long after repair is effected, it is a sub-normal tissue-inclusion in reaction with its environmental tissues, which are often not identical. A vast and complicated variety of cases occurs when the healing process does not follow the normal routine. As I said, the process depends on the fixed cells resuming their original proliferating function, but in doing so they are dependent on the blood supply, and on the blood and motor cells, which discharge various and important offices in the process. At first, a breach of continuity is simply a vacant space, which comes to be filled up by tissue elements undergoing transformation, and at all its stages the forming tissue corresponds to an inclusion in a state differing from the including area. As is evident, the latter alone is vascularized, commands a normal blood supply; the cells of the inclusion when it contains them, or comes to contain them, live like cells *in vitro* in a nutrient medium, though the medium *in vivo* is a specific form. Under the normal routine the medium corresponds to connective tissue, a tissue omnipresent in the body, and capable as a cellular formation of extreme transformation or modification. But the medium is derived from the environmental cells alone commanding directly a blood supply, and the included cells proliferating in the medium are dependent on it for maintenance, having no proper blood supply of their own. The condition of the new cell formation is very different from that of the including cell formation, but nevertheless it comes to exist in the absence of a vascular system of its own. The condition means that the new cells or tissue-inclusion, while dependent on its immediate environment, is independent of the systemic environment or organism, lives, or may live in it, without vascular or nervous connection with it.

This expresses the common condition for tumors and other inclusions, cicatrices being a partial exception. Normally, however, it is only a stage in new tissue formation only in minor degree permanent. We have seen that in the case of a carcinomatous graft, composed of connective tissue, and included cells, the former degenerates and is replaced by the connective tissue of the host. The same thing occurs when the graft is one of normal tissue; that is ultimately replaced by the connective tissue of the host, though some of its cells may remain unaffected. This follows from the fact that the graft tissue is not vascularized, and therefore degenerates while the tissue of the host is, and therefore grows into the graft as if it were vacant space. But the original and dominating fact remains that a cell, or some kind of cells, can live, and on occasion proliferate in an organism with which it has no true organic or systemic connection. The limitation which would make the cell a specific one, a kind of parasite, is removed when we realize that it has a generalized form which it starts with, and is throughout capable of resuming. The primordial single cell following a fixed routine, expressing like every routine continuity, develops from itself every organ and tissue of the body. We cannot say positively that every cell of the many millions which make up the body retains in every degree that generalized form, but every injury and breach of continuity tells us that they all retain it in some degree, even though they cannot always exert it. It is equally evident that the generalized cell form is under constraint in the metazoan cell system, is debarred in particular from the proliferation of which it is capable. This condition of mechanical constraint, fluctuating about a mean from an extreme degree to total absence is evident in the case of most inclusions or tumors. Most tumors are bound about on their own side, or that of their site by capsules, cysts, or simple condensed tissue, and the form this takes for individual cells is a sclerosed or hardened infiltration. A primary spontaneous carcinoma is typically a minute inclusion in which epithelial or skin cells are bound together in a sclerosed or condensed stroma or element of connective tissue. The evidence here that the cells are other than normal is altogether inconclusive; the condition under which they exist is enough, and that applies in equal or higher degree to the condensed stroma. Similarly, in the other common variety of cancer, the sarcoma, there is a tendency, even in advanced stages, to limit the disease by partitioning the tumor by fibrous or fibro-blastic elements of connective tissue.

It is to be noted that we have reached a point in which description is not of a cell diseased *ab initio*, but of a process deviation from which places it under abnormal conditions, to be usefully, though not exhaustively, looked on as mechanical. The process itself as normal is that which bases the construction of the metazoan organism or cell system on a resting or seed cell, the typical form of which is that of an anergid, able to resist transfer of energy from or to it, non-metabolic, remaining unaltered under wide changes in its environment. It is one of the illusions of present-day science, unfortunately dominating medical theories in particular, that the phenomena of life are expressible in terms of flux

* Reproduced from the *Westminster Review*.

of energy. As usual, the illusion is due to stating a proposition in an absolute sense, a crude fallacy in logic. Both the positive and negative form of the proposition have place in description of phenomena, and, discarding the term energy, as we would Mesopotamia, in this connection, what stands for description is when we have change of state, and when we have no, or limited, degrees of change.

Roughly speaking, a cell is a vessel full of fluid constrained to occupy a space which it would not if left to itself. If the cell dies or is broken the fluid is spilled, and obeys the law of its own nature. More precisely the cell contains many kinds of stuff, all of them under constraint in it, and stuff may enter it which disintegrates and destroys it. The many-celled system obeys the same condition; each cell is under mechanical constraint by its cell environment, and what has to be maintained is the constraint eventuating in a state of rest or equilibrium, which, for the whole system or organism, lasts an indefinite time. Each part of the organism, a differentiated cell group, is constrained to a position of rest by its immediate environment, and the environing groups are integrated into a whole.

Cancer research is tending in particular to show the importance of pure mechanical detail in the structure of organisms. A house, as a rule, does not drop into ruin by its stones and mortar decaying, and, even if they do to some extent, it may remain in a resting state for a long time. If, however, it is ill-built, its walls out of the perpendicular, its stones dropping or pushed out of proper place, it comes down at once, however sound the materials may be. The cell system is liable to the same structural defects; it may be ill-built from the first, or, in the course of time, the cells may be pressed on or pushed out of place, which secondarily means their becoming diseased or dying. But the house can be patched and repaired, and the cell, as itself a distinct vital agent, can adapt itself to new conditions of environment. The adaptation locally may be in the individual cell and in those about it, but in general a defect affects a cell group very unequally. In a wound a great many members of a local group die, which means that the normal degree of constraint on the remaining members is lessened or abolished. The constraint expressed, as I said, in some cases by imprisonment of cells in condensed tissue, in other cases is quite wanting. Cells are living creatures, and, like the creatures they build up, become criminals and lunatics under undue constraint, and play foolish pranks when the constraint they are accustomed to tolerate is quite abolished. To express cancer by a phrase it is cell anarchism, and, if not that, cell lunacy, defined by departure from a routine normally followed in metazoan cell grouping, whereby the cells become complexly inter-dependent. Cancer occurs in the whole vertebrate order, because the routine has a common mode of cell formation by proliferation proceeding from a single resting cell, and giving ultimately a disposition of fixed resting tissue cells. Departure or aberration from the normal disposition accounts for cancer among other diseases having a common form throughout the order. But the vertebrate cell itself has no common form, and in following a common routine in ontogeny preserves its specific individuality. The human cells, in proceeding from a single proliferating cell remain human cells, though following the common vertebrate routine remain human, even when they become cancer or other abnormal cells, and so for the mouse. This is shown in a striking manner by the fact that, although there is wide departure from the normal human embryonic routine whereby strange monstrosities are produced, these never depart from the human type, never approximate the characters of an animal of a different species. A mountain may bring forth a mouse, but the prolific mouse has never brought forth a homunculus. This observation bears on the Darwinian theory of the origin of species, since that theory gives no account of the origin of the specific cell as specific.

It may be thought that a foreign cell may be tolerated in a cell system as a bullet or other foreign body is, and as parasitic cells are through a wide range. The case is one not to be ignored, as it applies to misplacement of cells native to the species; in degree there is undoubtedly tolerance of these under the condition. That must be allowed as expressing a common relation between cancerous inclusions, and the animal in which they arise; up to certain points their effect on the general health of the animal is nil, indicating their perfect localization, the fact that they do not proceed from any constitutional cause, and produce no constitutional disturbance. This is a most important point, since the disease has been ascribed to excess of uric acid, sulphuric acid, and other matters in the system, an idea which would lead away from the proven efficacy of local treatment by the knife, or similar means. The point at which constitutional disturbance occurs, and the manner in which it arises, is, however, in the highest degree significant of the disease. As I have implied, the cancer and granulating cells in invariable connection, in proliferating free of systemic constraint, generate virtually every kind of cell, and among them motor cells. These, carrying with them the abnormal proliferating character of the parent tissue cells, become fixed in every part of the body, but chiefly in the lungs, reproducing proliferating tumors in many new sites. These, like the original focus, are essentially mechanical in their nature, but secondarily disturb the functions of the more vital organs, and vitiate their products, but there is no evidence to the effect that cancer *per se* has septic elements residing in its cells. This is one of many reasons for looking on these cells as normal under abnormal conditions, qualifying the statement by saying that the conditions are those of granulating tissue deviating from its normal routine in healing wounds or other breaches of continuity. In cancer both the inclusion and the site are granulating in the effort at healing, and the inclusions may not be original, but arise as interfering foci in a granulating site. In the disease there is always an included and including area, a departure from homogeneous tissue, and an effort to restore continuity by the resumption of the proliferating process in the cells of both areas which, as differentiated, are liable to deviation from the normal routine.

Looking at the four reports of the Imperial Research Fund and their well-nigh exhaustive references to all-important research into their subject going on, the reader will naturally ask whether any remedy for the disease is coming into view. The answer at present must be that research shows that spontaneous cure is frequent, and that induction of resistance to and immunity from the disease can reasonably be inferred, but that cure and immunity, natural and induced, must remain matter for further investigation. It may be a premature generalization to say that cancer is a purely structural disease due to cells otherwise normal and specific coming to live and proliferate in the body of the animal they belong to, that body serving them only as a nutrient medium, and binding them no longer to its organic routine. The generalization, however, such as it is, accords not only with the line of treatment, which, in the past, taking it as a local aberration of structure, would remove or destroy *in situ* the affected piece of tissue, but also with the indications arising in many directions in the course of systematic research. These indications point to poisoning or starving the peccant cells, rendering the nutrient medium unfit for them, or rendering them unable to avail themselves of it. The most recent cure for cancer is based on the idea that the rapid proliferation of the cells demands an extra supply of oxygen, and Prof. Wassermann, of Berlin, proposes to interfere with the supply by means of a compound of selenium and the aniline dye, eosin. The selective absorption of this compound by the cancer cells is supposed to limit their power of taking up oxygen, which may be construed as either poisoning or starving them. The remedy has been found to be successful for small cancers in the mouse, but, selenium, being a powerful poison, the dose to have effect on a large tumor, is fatal to the animal. But the relation of cell life to nutrient media is a problem as yet almost untouched, and the importance of the problem is shown by the fact that the carcinomatous cell degenerates when its proper connective tissue is replaced by that which maintains the sarcomatous cell. Where, in the case of a graft, there is no replacement of connective tissue from the host, the animal is immune, and the cancer cells necrose or die.

I can only faintly indicate the many points brought into view by recent cancer research, dealing as it does with a vast and complex mass of detail. But of both the present and prospective value of the research going on as bearing on both cancer and other diseases, on the nature of life itself, our note of appreciation must be free of all doubt.

The Unit of Heat.*

In response to an inquiry as to whether the heat unit had ever been legally defined or a standard unit adopted in the United States, Director S. W. Stratton, of the U. S. Bureau of Standards, writes as follows:

The British thermal unit has never been legally defined, nor have any international congresses, in their various steps toward properly defined and definitely related units of measurement, given any consideration whatever to this one.

Wherever it has been employed as a unit of heat it has been understood to mean simply the quantity of heat required to raise the temperature of 1 pound of water through 1 deg. Fahr., leaving the particular degree to be specified, if necessary, by the writer publishing the data in terms of such unit. The total variation of the specific heat of water between the freezing and boiling points being only about 1 per cent, and the difference in the heat units most likely to be used being but a small fraction of this, as set forth later, it must be assumed that when the term B.t.u. is employed without specifying any temperature at the same time, the data given are without significance in the figure where a consideration of this point would make an appreciable difference.

In very few, if any, cases where the B.t.u. has been employed in publishing data, has the work been of a nature to warrant the refinement of specifying the temperature. For the sake of comparison with the important work along the same lines in Germany, France and all other countries using the international metric system, aside from the advantage of the greater convenience in employing it, it is becoming more and more common in America to state heat measurements in terms of the units of this system, just as electrical measurements have from the very first been so stated.

The scientific unit of heat is called the calorie and is defined as "the quantity of heat required to raise the temperature of one gramme of water through 1 deg. Cent.," the mean temperature of 15 deg. Cent. (= 59 deg. Fahr.) being understood whenever no other is clearly specified. From time to time other units have been proposed, but they have not attained wide acceptance and when employed, they are clearly indicated.

From probably the best work so far done upon the variation, with temperature, of the specific heat of water, the following values are quoted:[1]

In terms of the 15-degree calorie as a unit for comparison, the 4-degree calorie = 1.004 15-degree calories. Four deg. Cent. = 39.2 deg. Fahr. (The 4-degree calorie has been proposed because of the maximum density of water occurring at about this temperature.)

The 15-degree calorie = 1 15-degree calorie. Fifteen deg. Cent. = 59 deg. Fahr.

The 20-degree calorie = 0.999 15-degree calorie. Twenty deg. Cent. = 68 deg. Fahr. (The 20-degree calorie has been proposed on the ground that a mean temperature about that of the usual laboratory possesses decided advantages.)

The 25-degree calorie = 0.999 15-degree calorie. Twenty-five deg. Cent. = 77 deg. Fahr. (This calorie was proposed as advantageous because from 20 to 30 degrees the extreme variation is but a few parts, probably 2 in 10,000, whence no careful temperature precautions would have to be taken in work involving a direct employment of the unit.)

The mean 0 to 100-degree calorie = 1.0044 15-degree calories. Zero deg. Cent. = 32 deg. Fahr.; 100 deg. Cent. = 212 deg. Fahr. (This calorie is independent of the temperature scale, gas, mercurial, resistance, etc., since 0 and 100 degrees are always fundamental points.)

By the definition of the Fahrenheit scale and the internationally fixed Centigrade scale, the ratio of the two degrees is 1.8. The legal definition of the pound in the United States defines it to be a certain fraction of the international kilogramme, the decimal value of which fraction to five figures makes 1 pound equal to 453.59 grammes. With the same mean temperature, 1 B.t.u. is therefore 252.0 calories, or

One B.t.u. (59° Fahr.)	= 252.0* 15° calories[2]
One B.t.u. (62° Fahr.)	= 251.9* 15° calories
One B.t.u. (39° Fahr.)	= 253.0 15° calories
One B.t.u. (32° to 212° Fahr.)	= 253.0 15° calories

The unit of heat officially used in this bureau is the 15-degree calorie. Upon request, data are sometimes expressed in terms of British thermal units, the mean temperature of the unit employed being stated when the precision of the data requires differentiation. The 60- or the 62-deg. Fahr. B.t.u. (being for all practical purposes identical with the 59-deg. Fahr. = 15-deg. Cent. one) is probably more often used by the bureau than any other.

* Reproduced from *Power*.

[1] Bousfield & Bousfield, Phil. Trans., Royal Society, series A, Vol. 211, page 199, 1911. "The Specific Heat of Water and the Mechanical Equivalent of the Calorie at Temperatures from 0° C. to 80° C.

[2] These are the small or gramme calories.

Production of an Adhesive Very Sticky with Cold Water.—Mix starch or starchy substances thoroughly with water and heat the paste, for instance, by spreading it in a thin layer on heated rolls, so that at first a sort of dough and then a dry mass is obtained, which is removed from the rolls in the form of flat cakes. The rolls, for this purpose, must be heated to 110 deg. Cent. Before or after heating an alkali or an acid is added to the finely divided or dried starch paste to increase its adhesiveness. Examples: (1) 100 parts of finely ground potatoes are mixed with 0.5 part of hydrochloric acid (specific gravity 1.2) and 300 parts of water, the paste smeared on rolls heated to 110 deg. Cent., and the dried starch mass ground fine. The starch paste can also first be changed into the doughy form at 750 deg. Cent. and then converted into dry form at 110 deg. Cent. (2) 100 parts of starch flour are thoroughly mixed with 500 parts of water, then heated, in thin layers, on steam-heated rolls to 120 deg. Cent. The dried mass is finely pulverized and 2 parts of pulverized sodium carbonate mixed with it.—*Farben Zeitung*.

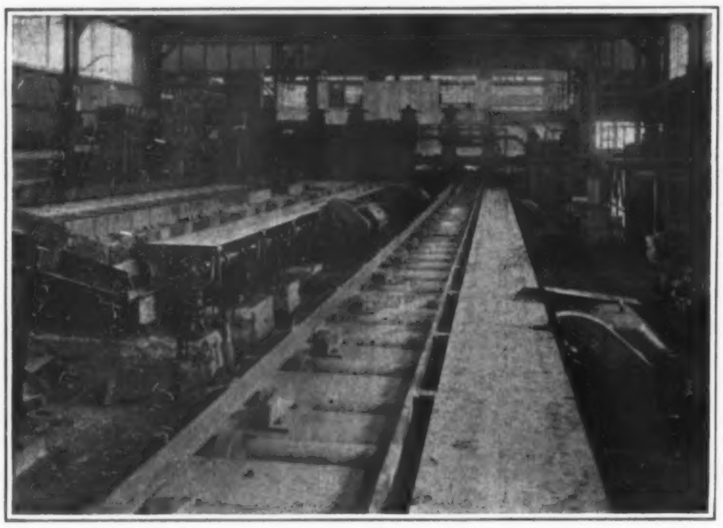


Fig. 1.—View In the Shop with Switchboards on Right and Left for Handling the Inclosed Type Motors.

Fig. 2.—Inclosed Electric Motor for Handling the Rolls Which Serve the Electric Saw.

Electric Reversible Rolling Mills and Auxiliary Equipment

For a number of years electric power has been employed in iron and steel plants in America as well as in Europe and it is becoming more and more extensively employed for this service, but until recently reversible rolling mills have been operated exclusively by steam power, although the auxiliary apparatus has been electrically driven to great advantage.

As indicated in the accompanying illustration Figs. 1 and 2 inclosed electric motors similar to those used in railway service have been employed for driving the live rolls controlled from switchboards mounted in elevated platforms at the sides of the mills. The photograph Fig. 5 illustrates the method of mounting the same inclosed type of motor on the top of the frame of the mill, similar motors being used for moving the rails over the hot beds.

The open type of direct current electric motor has been largely used for driving the hot saws for cutting the rail the proper length as indicated in the upper front page illustration, the same type of motors being employed for operating the rail straightening machines, a group of which may be noted in Fig. 4.

In Tyrzynietz, Austria, there has been in operation for some time at the Hildegardenhütte, a successful electric reversible rolling mill which is of special interest. A large electric power generating station was built for this great iron and steel plant in order to centralize the power installation and do away with a number of scattered steam driven power stations.

A modern steam turbine electric power generating plant was installed which includes a turbo-alternator having an output of 5,000 kilowatts. Two steam turbines and electrical generators of the Curtis and Allgemeine Electrizitäts Gesellschaft type were employed.

There are three units operating in parallel and the Curtis A. E. G. turbine has a steam consumption of 15.9 pounds per effective kilowatt hour, the steam pressure being 8 atmospheres with 300 degrees superheated steam and 95 per cent vacuum.

In order to insure the greatest economy in the centralized electric power generating and distributing system it was thought better to change the reversing rolling mill for electric drive, it formerly having been operated by a steam engine using steam with admission pressure of 6 atmospheres and having a stroke of 4.1 feet and a cylinder of 3.93 feet in diameter.

This reversing mill consists of four frames with blocks weighing 2 tons, the dimensions being 66.9 inches by 17.7 inches by 16.5 inches. It is designed for rolling double T-girders up to 1.8 inches in height. These rolls are driven electrically by three motors of the continuous current type directly coupled together and to the rolling mill shaft. They operate in the same manner as a single electric motor, the only difference being that the inertia of the rotating system is greatly reduced by the subdivision of the power into three motors.

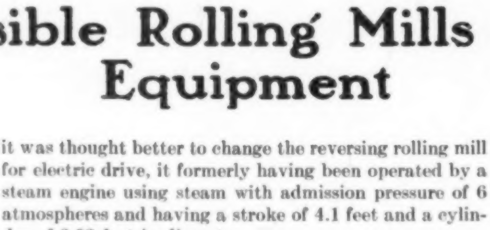


Fig. 3.—Inclosed Electric Motors Driving Live Rolls.

In some recent plants where there is a maximum load of 15,000 horse-power, it has not been considered necessary to sub-divide the power to such an extent, and two motors do the work satisfactorily instead of three; one plant has also been installed with an electric reversing rolling mill with only a single motor, even with a maximum load of 7,500 horse-power.

The rolls can be accelerated to a speed of 100 revolutions per minute from zero in two or three seconds when running light. Even under wide fluctuations of load at the rolls, at the central station fluctuations rarely vary 100 kilowatts above or below the 500 kilowatt mean value, while the energy consumption varies from 20 to 60 kilowatt hours per ton of completed product as rolled from the raw material, this variation being due to the nature of the product being turned out.

The Ilgner motor generator set includes two direct current generators of 1,500 kilowatts each with an induction motor of 2,500 horse-power between them and a heavy fly-wheel of 26 tons between each generator and the motor. The induction motor is supplied with current at 3,000 volts pressure and the fly-wheels maintain a peripheral speed of about 262.5 feet per second.

The Ilgner set has a speed of 320 revolutions per minute the slip being automatically regulated down from the synchronous speed of 375 and Polysus special flexible yielding couplings are used between the motor and the fly-wheels. The speed sometimes falls to 300 revolutions per minute when abnormal torques are required.

The three electric motors driving the electric reversing rolling mill are connected in series and supplied from the direct current end of the Ilgner set at 100 volts, the two dynamos of this set being connected in series and each supplying a normal maximum pressure of 500 volts. It takes about 5 minutes for the Ilgner set to reach its full speed of 320 revolutions per minute when supplied with from 600 to 800 kilowatts and proportionally shorter time when more current is used. It takes about 120 kilowatts to run this set unloaded, and the machines although having a normal capacity of 1,500 kilowatts are capable of giving nearly 4,000 kilowatts each at 500 volts without burning out, the circuit breaker of the secondary being set at 9,000 kilowatts.

The load on the generating station is comparatively constant at about 550 horse-power, in spite of the rapid and great load changes at the motors, this steady demand from the power plant being due to the fact that the Ilgner set very effectively equalizes the fluctuations that would ordinarily fall upon the generating power plant.

One of the features of the electrical equipment of this

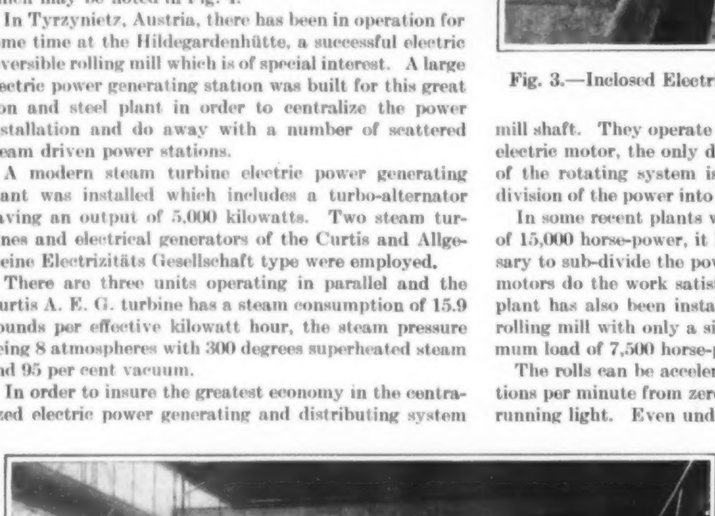


Fig. 4.—Rail Straightener, Operated by Open Type D. C. Motors.

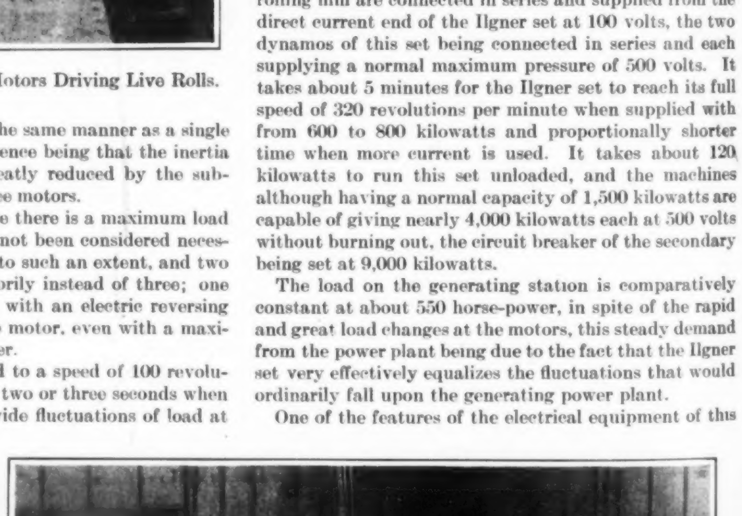


Fig. 5.—Electric Motor Equipment on the Mill Frame for Handling the Rolls.

plant is the exciting motor generator set which includes two continuous current dynamos with one induction motor driving the same, the shunt windings of the rolling mill electric motor as well as the Ilgner direct-current dynamos being excited from one of these dynamos while the other dynamo for this small motor generator set supplies current to special compound windings arranged so as to strengthen the field of the motors when there are sudden abnormal changes in the load. This brings about a lowering of the speed and instead of the line being heavily overloaded as would otherwise occur, it is instantly relieved by the decreased speed.

Directly in front of the high-tension switchboard gallery there are installed two motor generator sets of 200 horse-power each for lighting service. The accompanying illustrations and drawings show the arrangement of the electrical equipment.

Another rolling mill at Hildegardenhütte is electrically operated by two direct-coupled three-phase motors of 750 horse-power with a maximum output of 1,500 horse-power. One of these motors is designed for a normal speed of 167 revolutions per minute and the other for 215. In this case rope transmission is used, the pulley on the double motor set being 141.7 inches in diameter and driving a large pulley on the rolls 18.4 feet in diameter.

There are two other mills operated electrically at the iron and steel works at Tyrzynietz, each of which is driven by a double three-phase motor set of the same type as that above described, each motor having a normal output of 750 horse-power and a maximum of 1,500 horse-power with speeds of 167 to 215 revolutions.

Each double motor drives two sets of rolls, one set by direct connection and the other by belt and rope transmission. Where rolling mills do not have to be reversed electric power can be applied without difficulty and this form of power is greatly valued, as not only economical but easily controlled and allowing a centralization of power not possible where steam engines are necessary.

The utilization of waste blast furnace gases for operating gas engine power plants for iron and steel works, makes it particularly desirable that a successful reversing mill with electric drive be developed, and it is now maintained that the tests at the Hildegardenhütte prove beyond a doubt that electric power can be used for this service most successfully.

Good Road Building

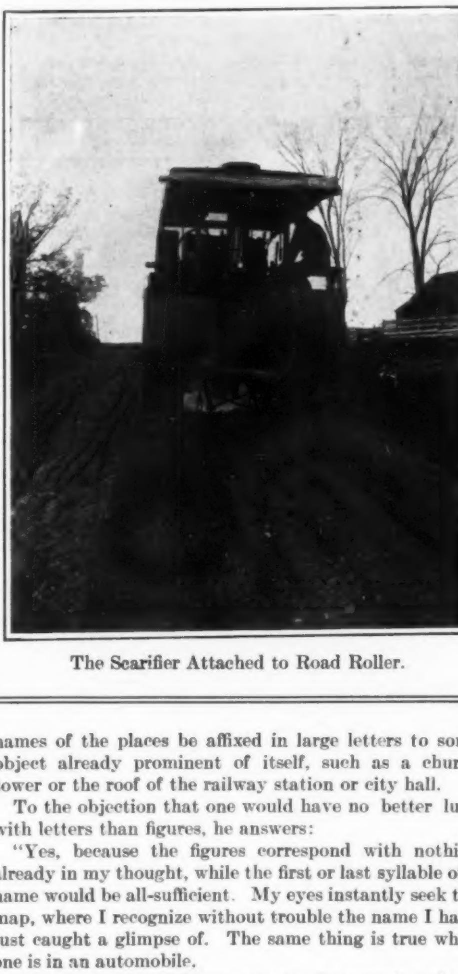
The Scarifier and Roller

The accompanying illustration shows a modern road roller with scarifier attachment, owned by Logan County, Ohio, and at work near Bellefontaine. By the use of this scarifier and steam roller at Princeton, Indiana, it was possible to cut out the expense of five teams on the grader by putting on the engine pull and hooking the roller to it. The rolling and grading sub-grade was accomplished in one round, throwing up the banking dirt, running the ditcher line, and throwing the shoulder on the road, without causing the haulers to lose time.

The construction of the scarifier is not at all complicated. The device consists of a heavy Z-shaped bar, as long as the width of roller at the rear. Attached to this bar are nine heavy spikes, of such shape, and set in such a way, as to be drawn into the ground when pulled forward by the roller. The effect of this is to break up the hard crust or surface of an old macadam or gravel road, and leave it in shape to reconstruct the load.

The connection from the bar is made to the rear axle of the roller and all the pulling strain comes there. Directly beneath the boiler a simple cylinder is placed. Steam is piped to this cylinder from the top of the boiler. By moving a lever at the engineer's side on the platform, steam is admitted to the cylinder to either raise or lower the scarifier. When raised, the spikes clear the ground, so that they do not interfere with any other operation of the roller. When lowered, they are forced into the ground and held there by steam pressure. It takes but a fraction of a minute to raise or lower them.

An interesting feature is the manner in which the spikes are held down. The piston acting against the steam in the cylinder gives cushioned compression; and this flexibility prevents damaging the apparatus



The Scarifier Attached to Road Roller.

in case of striking solid rock. The spikes slide over the rock, but are forced down again immediately after passing. In tearing up a street, the surface may be torn right up to a crossing then the spikes raised, carried over the walk, and dropped on the other side without stopping the roller.

It is claimed that this attachment has demonstrated that it will do the work and much better and cheaper than it can be done by a detached machine. After the surface is broken up, the old material is put in shape by the grader, and the job completed by rolling; giving practically a new road at much less cost than a new one.

This steam roller has a boiler of the return-flue self-contained type. This assures economy in the use of fuel and water; the heat is carried twice through the water in the boiler before it can escape to the stack. The boiler is quickly fired and it is easy to hold fire over night, which often saves annoying delays waiting for steam.

An important point about this roller is that the outfit is propelled by its own power. This is an excellent feature, and one fully appreciated by the operator as the guide is controlled simply by a straight lever at either side of the platform. The weight is distributed so as to give the correct proportion of compression at the front and at the rear.

The front roller is made in three equal sections, with heavy spokes at each side of each section and the rear rollers have cast steel rim, with very heavy spokes riveted to hub and to lugs cast in the rim. The roller is provided with full canopy top, and heavy canvas side and end curtains reaching to the ground.

The Paths of Space

The Aero Club of France has just published a very comprehensive map for the special use of aviators. Routes are marked with heavy lines, and all important points and outstanding landmarks are indicated, together with dangerous spots and desirable and undesirable places of landing, rivers, bodies of water, canals, cross-roads, railroad crossings, etc.

There has been a good deal of agitation for months past in regard to the establishment of an artificial system of signaling for air men. Various plans have been proposed and to some extent put in practice, such as spreading large strips of white cloth on fields or roofs, building coal tar fires whose rolling clouds of heavy smoke form a signal like that of the Israelites of old, and finally an elaborate code of figures and lines of huge size erected on roofs and sometimes composed of electric lights.

In cases like this the proof of the pudding is in the eating. Hence the opinion of a practical aviator as to the positive value of such theoretical aids is of the utmost weight. Such an opinion has just been given utterance by Emmanuel Helen in the pages of *Je Sais Tout*.

M. Helen is the winner of the Coupe Michelin for 1911. He is the only aviator thus far to achieve a record of a thousand kilometers in a day's flight, and has a further record to his credit of a total of 12,000 kilometers covered in less than two months in his Nieuport machine. He is therefore highly competent to speak upon this subject.

He cannot refrain from indulging in a little gentle irony at the expense of the advocates of the code system of figures referred to above—the "aerial signaling"—to the effect that it is very kind of these good people to think of the poor aviators, but that unfortunately it is difficult to make out such objects even when flying slowly above a roof, and quite impossible at a speed of a hundred kilometers or more per hour. Then, too, the system demands a close study of the meridians and of the way the figures are placed, underlined, and combined. In brief the advantages of the plan are more than offset by the fact that it is troublesome, time taking and confusing.

Helen makes the sensible suggestion that the actual names of the places be affixed in large letters to some object already prominent of itself, such as a church tower or the roof of the railway station or city hall.

To the objection that one would have no better luck with letters than figures, he answers:

"Yes, because the figures correspond with nothing already in my thought, while the first or last syllable of a name would be all-sufficient. My eyes instantly seek the map, where I recognize without trouble the name I have just caught a glimpse of. The same thing is true when one is in an automobile.

"In the circuits of flying contests the organizers have always desired to erect a serviceable system of signals, but they have never hit on anything to suit us. Arrows on the roads or fields, captive balloons flying a hundred to a hundred and fifty meters above the ground look quite wonderful to the pedestrians who reflect on how much solicitude is shown for these human birds. Unhappily, these are the only ones who can't see them! And if by an extraordinary chance they are visible they are mostly placed at points where they are useless."

The aviator recommends that such marks should be placed at points where mistakes are apt to occur; such as cross-roads and railroad crossings, and considers coal tar fires the most useful form, but says they are not worth half as much as a good map and compass.

"Every serious aviator," he says, "should learn to read his map, study it, and commit it to memory. He should mark upon it all visible points, canals, forests, churches, railroads, cross-roads."

In clear weather the map alone is sufficient. The aviator flies high, since the higher he goes the more nearly does the ground resemble his map; moreover in case of accident to the motor, it is easier to select a landing place and make a safe downward glide.

Unfortunately perfect clearness of the atmosphere is very rare, and here is where the compass comes into play. It is placed in front of the pilot, and the map, provided with holder and roller is at one side. The holder must be firmly fastened and the roller in perfect working order, else the map may tear, or stick tight, or slip out of position at a critical moment. "It is relatively easy to steer by a compass. But it is indispensable to possess one which is well compensated so as to register a minimum deviation. Once sure of this essential instrument, you mark the angle of direction on the map before starting, not without having studied the exact velocity of the wind, so as to be able to make the necessary correction en route. This correction is varable according to the speed and direction of the wind.

"At starting you mark on a straight line the angle of deviation formed by the machine with the ideal line. This angle, corrected by the compass and increased or diminished as the case may be, should give the line which you ought to follow on the condition that the wind does not vary during the trip. You look at your watch when you catch sight of a land-mark on the ground and determine whether you are passing over the spot you planned to reach at a given time by a given speed."

In foggy weather or when passing through clouds orientation is of course very difficult. "In clouds the compass is magnetized by the ambient electricity; it no longer seeks the North and spins like a top. This phenomenon is caused by the magnetization, the trembling of the motor, et cetera. When traversing clouds you constantly encounter eddies and continually change your level because of successive rising and falling. The only thing to do is to approach the earth, taking care not to bump into a hill, which is the greatest source of danger in low flying in foggy weather."

In such weather it is advisable not only to fly low so that the ground and the more important landmarks may at least be glimpsed, but to abandon the idea of making a "bee-line" between two points, and to follow instead some known and well-marked pathway, such as a railroad line, a river, or a canal.

In this way many long detours and turns will necessarily be made in most cases, but the extra time required will be less than that which would be required for returning to the starting-point after losing the way once or twice. Following water-courses offers the advantage of affording safe landing places.

The Commercial Development of India Rubber*

A Historical Review

By S. Frankenburg

THE first notice of india rubber or caoutchouc we can trace is to be found in a work written by Antonio de Herrara y Tordesillas (published at Madrid from 1601 to 1615), describing the voyages of the Castilians from 1492 to 1554. In this mention is made of the natives of Hayti playing a game with balls made from the gum of a tree, doubtless india rubber.

Again, in dealing with the conquest of Mexico, the Castilians found trees in which the natives made incisions from which there flowed a milky substance that converted itself into "a white gum with a pleasant smell." Juan de Torquemada, in his book, "The Indian Monarchy," published in Madrid in 1615, was the first to give an accurate description of the leading characteristics of the tree ("Ulequahuiti," or *Castilloa elastica*) which yielded this gum, and of the method employed by the Indian natives to collect it. Torquemada states that the Indians used the rubber for medicinal purposes, and that the Spaniards in Mexico were the first users of waterproof cloaks.

In 1736 Lacondamine sent to the Paris Academy of Science from Brazil a dark, resinous lump of caoutchouc, from which the natives made torches. He later found the Hevea tree growing along the banks of the Amazon. The Indians of this district gave the name of "Cahucha" to the resin, the waterproofing properties of which were well known to them.

In 1762, Fusset Aublet, a French botanist, discovered the rubber tree in French Guiana, and named it *Hevea Guyanensis*; while about the year 1765 another Frenchman, M. Coffigny, found rubber trees in the Island of Madagascar.

During this time the new resin was the object of study by a number of chemists with a view to making use of it for manufacturing purposes. Their great difficulty was to find a good solvent.

In 1761 Hérissant and Macquer found a satisfactory solvent for caoutchouc. By dissolving it in oil of turpentine rectified over lime they obtained a pasty mass which allowed the rubber to regain its former elastic state. They pointed out also that ether might also be used as a solvent.

In 1770 Dr. Priestley found that rubber could be used for erasing pencil marks, and Magellan introduced this use of rubber into France in 1772. The price at that time was about 20s. an ounce.

In 1798 rubber had been found in Penang, by Mr. J. Howison, who discovered the tree known as *Urceola elastica*, and shortly afterward in Assam by Dr. Roxburgh. The tree he found there was the *ficus elastica*.

In 1791, Samuel Peal took out the first patent in connection with rubber, "For application of dissolved india rubber to waterproofing, the solution in spirits of turpentine to be spread over the fabric with a brush." Peal does not seem to have done anything with this patent, and it was twenty-nine years before the next patent was taken out, this being granted to Thomas Hancock on April 29th, 1820, and was "For an improvement in the application of a certain material to various articles of dress and other articles that the same may be rendered more elastic."

In 1823 Charles Macintosh brought out a patent for waterproofing fabrics by a solution of india rubber in coal oil or naphtha, and established a factory for the manufacture of waterproof articles at Glasgow. This factory he later on moved to Manchester. He formed a partnership with the Messrs. Birley, the firm being called Charles Macintosh and Co. This is still one of the largest factories in this country (Great Britain), and although there is now no Macintosh in the firm, the third and may be the fourth generation of the Birleys are still actively connected with it. It was in Manchester then that Charles Macintosh began to make those waterproof coats which still bear his name.

Up to this time the rubber had been coming into the country in the form of bottles and of figures, and a difficulty was found to get the material of uniform thickness. Hancock in London during 1826 had made for him a machine worked by man power to masticate the rubber. This machine would take a charge of one pound. Next year he moved to a larger place in Goswell Road, where he had a horse mill put up and fixed here larger masticators, and also iron rollers through which he passed the raw rubber when hot, which process he found formed it into a rough corrugated sheet, thus bringing it into a good state of preparation for the masticator, and also greatly facilitated drying. The charges he was now putting into his machine were of 14 to 15 pounds in weight. The same machines are still used to this day with very few alterations, with the exception that they are much larger.

Hancock was now manufacturing all kinds of elastic articles such as garters, braces, knee-caps, surgical bands, etc. In 1823 he commenced making billiard table cushions, and in 1826 he was making rubber driving belts for machinery and card fillets for carding machines. He had in 1825 taken out a license from Macintosh for the use of his patent. This he now began to apply to air-beds, air-cushions, etc. He also made life preservers of rubber. About this time his brother, John Hancock, started making rubber hose which was taken up in the first place by breweries. Thomas Hancock next took in hand the manufacture of diving suits and tubes for supplying air to the diver. In 1828 he started a factory in Paris principally for the manufacture of elastic webbings.

In 1830, Hancock joined Charles Macintosh and Co., still, however, keeping up his place in London. During the next few years other people started experimenting with the manufacture of rubber articles.

The one disadvantage of the waterproof articles manufactured by Hancock and Macintosh was, that they would not stand the extremes of heat and cold. In 1832 a German chemist, Ludersdorf, discovered that sulphur mixed with rubber dissolved in turpentine took away the viscosity but he does not seem to have gone further in the matter.

It was an American, Nelson Goodyear, who first solved the great secret of how to produce rubber articles which would keep their nature in the extremes of heat and cold. Goodyear's partner, Nathaniel Hayward, accidentally dropped on a heated stove some rubber mixed with sulphur, and afterward noticed how the sulphur was taken up by the rubber, which itself became elastic and kept its nature when afterward exposed to the sun's rays. This was in 1839. Goodyear saw the possibilities of this discovery and further developed it. He had already been experimenting with rubber dissolved in alcohol, and in 1836 had secured a contract from the U. S. Government for waterproof mail bags, which, however, had been found useless at high temperatures. Goodyear finally took out an American patent in 1844 for his vulcanizing process.

In the meantime, however, Hancock had in 1843 taken out a British patent for practically the same process, so that when in 1847 the Hayward Rubber Company of America started importing rubber overshoes into this country, they were challenged by Charles Macintosh, who stated they were infringing Hancock's patent. The matter was, however, arranged amicably by Macintosh granting the American firm an exclusive right to sell in this country overshoes of their own manufacture.

In 1846 Alexander Parkes took out a patent for the cold cure or vulcanization process, which consists in immersing rubber in a solution of sulphur, chloride, and carbon bisulphide. This process showed that heat was not necessary for the vulcanization of rubber.

Rubber at this time was replacing leather for many purposes. In addition to the uses already mentioned it was now being used for steam valves, for door springs, for railway buffers and also for rollers for printing. It now came into use for carriage tires, and in 1850 Lieut. Halkett, of the Royal Navy, brought out his rubber collapsible boat, which is still used by many a yachtsman. The use of rubber for manufacturing purposes was now becoming very widespread, and during the next thirty years new factories were springing up.

In 1886 a patent was granted for printing patterns on the rubber face of faced cloth, and about the same time a process was brought out to get rid of the smell from waterproof cloth, which had prevented the macintosh from being very largely used. These two processes brought the waterproof garment into much wider uses, more especially for ladies.

About this time also the bicycle was becoming popular, and the manufacture of bicycle tires gave a further impetus to the rubber trade. This further strengthened by the introduction of the pneumatic tire by Michelin and Dunlop.

The great development in electricity for lighting and power purposes also created great demands for rubber for insulating purposes.

Next came the great development in the use of motor cars, which made a further demand on the rubber industry; in fact with the lowering in price of motor cars, which brought them into popular use all over the world, and the resultant demands for tires, the demands for raw rubber had become great, and was increasing so rapidly, that in the beginning of 1910, there was a temporary shortage of supply, which with the help of speculation sent up the price of Para rubber in less than eighteen months from 2s. 9d. ($0.66) to 12s. 6d. ($3.00) per pound.

The following figures will serve to show the great increase in the demand for rubber. In 1830 the total export of rubber from America was 25 tons. In 1850 this had grown to 750 tons. In 1870, 1,500 tons. For the season 1900-1901 the receipts of rubber of Para alone was 27,600 tons, while in 1910-1911 the receipts of Para was 37,500 tons. Besides this increasing quantities were being exported from Africa and from the Eastern plantations.

Plantation rubber.—It was in June, 1876, that the first supply of *Hevea* seeds was introduced into England. Mr. Wickham having collected them in the Amazon Valley on behalf of the Indian government. A few weeks later, 7,000 seedling *Hevea* plants, grown from these seeds at Kew, were sent to the Eastern tropic Botanic Gardens mostly to Ceylon. To show what bearing the plantations will have on the rubber market in the near future, the amounts of rubber exported from there during the last few years have been as follows: 1908, 2,500 tons; 1909, 4,600 tons; 1910, 7,050 tons; 1911, 12,000 tons.

* Paper read before the Manchester Section of the Society of American Industry, and published in its *Journal*.

Sitophobia: a Digestive Phantasm*

Aberrations of the Appetite

By George M. Niles, M.D., Professor of Gastroenterology and Therapeutics, Atlanta School of Medicine

SITOPHOBIA, signifying a morbid fear of, or aversion to food, merits the consideration of every thoughtful student of dietetics. Though the term itself is of somewhat recent use, the condition is an ancient one, being one of the manifestations of those peculiar "distempers" in which certain foods were repugnant or even dangerous, and in which the horror of some highly esteemed viands was ascribed to demoniac possession.

From the days of "nervous prostration" we arrived by easy stages to the period of "neurasthenia," and then, with a closer insight into various nervous and psychic states, came the present-day psychasthenias and obsessions and phobias. In the same class of phobias as comes the fear of high places, or of open places, or of closed rooms, may be placed sitophobia, with its fixed and often apparently causeless antipathy to some articles of food. Frequently this phobia is confined to a single viand. Probably every physician who reads this study will call to mind a patient, who fancies that some ordinarily harmless article contains for her or him a dreadful potentiality for evil. The patient will explain that since a child this article has been tabooed, and that to eat it would invite direful consequences. Close inquiry may elicit the admission that the aforesaid article has never been eaten, but perhaps it disagreed with some other member of the family and the inference has been drawn that it would necessarily act as a poison to this particular individual.

I have in mind a neurotic traveling salesman, who is morbidly afraid of butter or any dish prepared from it. The sight of butter on the table before him fills his mind with fearful forebodings, while much of his pocket money is spent in tips to waiters and cooks that nothing may be served him containing this evil agent. An eminent neurologist of New Orleans, some months ago, related to me the experience of a citizen of Louisiana, who developed a phobia for garlic, a flavoring agent of high repute in some sections of that State. As

* Reproduced from *The Medical Record*.

nearly all of the savory French and Spanish dishes there contain a "touch" of this somewhat pungent condiment, the patient, who lived in a hotel, found his protein diet extremely restricted. One day, however, in desperation, and at the earnest solicitation of his physician, he partook of a dish containing a little garlic, but he required his medical attendant to stay by his side for six hours to save him from the disastrous consequences anticipated by his abnormal imagination. Finding that he was not injured nor even distressed his phobia fortunately disappeared, and he has since relished the toothsome flavor imparted by this bulb of ancient use, the same that comforted the laborers as they built the pyramids for Cheops, and for which the Children of Israel yearned on their dreary journey in quest of the Promised Land.

As the years go by, and the physiologists delve more deeply into the underlying factors controlling various digestive phenomena, we are disposed to accord to these factors more respectful consideration. Since the epoch-making experiments of Beaumont upon the Canadian voyageur, St. Martin, the chemical functions of the stomach have been fairly well understood. The mechanics of the stomach and intestines when disposing of a meal have also been graphically depicted by Cannon and made clear by many demonstrations with the Röntgen ray. Up to quite a recent date, however, insufficient weight was allowed the psychic factors responsible for the excitation or inhibition of these juices, or for the orderly movements accompanying physiological stomach and intestinal digestion. Briefly stated, when food is taken the secretion first inaugurated is due to the sensations of eating and of taste, that is, it is purely a psychic secretion. The afferent stimuli, whose duty it is to transmit messages of gastronomic interest, originate in the mouth and nostrils, and these stimuli, in their intelligent manner, send the necessary tidings through the afferent path containing the secretory fibers, which path is embraced in the vagus nerve. This psychic message insures the beginning at least of gastric digestion, though its effort is supplemented by further action arising in the stomach itself.

Certain foods contain substances called secretagogues, which are capable of causing a flow of gastric juice when taken into the stomach, for instance, meat extractives, meat juices, soups, etc. Other foods bland in quality such as bread and white of eggs, are lacking in these ready-formed secretagogues, and have to depend practically on the psychic secretions for their digestion. In addition, there are substances generated in the intestinal and pancreatic secretions, designated by Starling hormones, from a Greek word meaning to arouse or excite. These hormones are influenced by the food ingested, varying from a slight to a potent effect, and to a marked extent regulating the various digestive juices, so that both the amount and specific quality are supplied according to the mechanical and chemical needs. These needs are previously interpreted by the psychic sensations evolved, so that it can readily be seen how the mental impress of food as it is eaten may regulate the supply and character of the necessary juices for its digestion; how a placid and cheerful frame of mind may aid the organs concerned in the bodily upkeep, or how a distaste or antipathy may, as it were, "dry up the fountains" for certain articles, converting them to all intents and purposes into foreign bodies. Thus, it is apparent that a violent dislike or fear amounting to a phobia for any particular foods, will, through the influence of these hormones, exert a real and tangible inhibitory effect on the special agencies required for their digestion, and that to force a fearful patient to eat them might result in serious damage.

The borderline between nervous anorexia and sitophobia is but dimly drawn. The former may deepen into the latter, or the sitophobia may dwindle down to a simple, unreasoning dislike, unexplainable to the patient himself. Such a dislike may be ascribed to temperamental peculiarities, to education, or to environment, and to trace back some of these antipathies or phobias to their starting point is often interesting indeed. Several instances will be mentioned that have come under my personal observation.

A gentleman of intelligence relates to me that when a lad on his father's farm there grew an apple tree right at the stable. This tree which was of the "June apple" variety exhibited a most luxuriant foliage and bore immense quantities of luscious red apples; but, knowing the immediate cause of this bountiful fruitage, he could never eat any of the apples from that tree nor has he to this day been able to eat any June apples. The sight or thought of them sets up a train of disgusting associations which would disturb his whole digestive apparatus were he to attempt to partake of them.

Some years ago a disciple of Izaak Walton betook himself to the Flint River, a Georgia stream, at a time when it was high from a recent freshet. Finding a promising eddy, where the swirling waters circled under an overhanging willow, he began fishing, and, to his gratification, soon caught an amazingly large number of fine catfish. Two days later he decided to again seek that spot, but when he arrived, the fallen river disclosed the putrid carcass of a cow, entangled in the débris collected by the eddy, and he quickly understood his phenomenal "catch." From that day to this he has never been able to eat catfish, nor can he enjoy a meal when any of this fish is on the table.

Another etiological factor in producing a sitophobia is a disagreeable or painful personal experience with some food or food product, as the following shows: A lady of mature years informed me that, when a little girl, she was inordinately fond of apple dumplings, thinking she could never get enough. On one occasion, however, the cook made a special baking of the coveted delicacy, so as to permit this youthful epicurean to have her fill. The result was a severe attack of indigestion, leaving in its wake a phobia for apple dumpling that time has not erased.

One of the most fruitful causes of the various sitophobias lies in the "half-baked" writings of self-appointed health teachers, who with lurid philippics hurled at some of our most wholesome articles of food, couched as they are in attractive language, and bolstered up by specious arguments, create injurious dietetic fads. I have in mind one religious sect who constantly inveigh against meat, so that some of its members possess a real sitophobia for this most economical protein. Thus we find the cults and isms, the schools of "new thought," the vegetarians and fruitarians, and others, who with a cheerful ignorance, flavored with more zeal than discretion, are constantly sowing the seeds of fear for the very classes of food most necessary for the well-being of the bodily economy.

Man is essentially an omnivorous animal. Our food customs are not of recent date but are evolved from the earliest antiquity; they are built upon the inherent needs of the human body, as interpreted by countless millions, and to lightly cast aside the rational dietaries fixed by the natural craving not of individuals but of nations and peoples would invite nutritional disaster.

The chronic dyspeptic especially of the nervous type furnishes the most comprehensive sitophobia. Ascribing, sometimes correctly, sometimes not, his ills to certain articles, he proceeds to omit one after another, eschewing the ones he most loves, and, as it were "crucifying the flesh" at the fancied behest of a finical stomach. These are the melancholy examples of an unreasoning phobia for the very viands for which a starving body is crying night and day, and whose inarticulate wails react on the entire personality, souring the disposition, depressing the spirit, and clouding the mental horizon.

The question now arises, how to manage this phobia; how shall we induce a distorted digestive viewpoint and a recalcitrant stomach to "get in line?" Suggestions must, of necessity, be general, embracing more of the psychic than medicinal, more of the educational than coercive. Children should be informed that a varied diet is the heritage of civilization and that a restricted one is a step backward toward savagery. The domestic sciences, including cookery, should be more universally taught, for often a sitophobia is first started by badly cooked or ill served food, which may cause either bodily distress or mental disgust; it little matters, the results being the same. Actual idiosyncrasies should be respected, but they are not as frequent as one would suppose. A mere dislike does not constitute an idiosyncrasy, nor does a phobia necessarily render an article indigestible, though, as previously mentioned, an inhibitory psychic influence may be exerted, militating against its easy digestion.

In order to act with intelligence and confidence, the physician should investigate both the secretory and motor functions of the stomach, and if they are found in fair condition he should set about gaining the patient's confidence, thereby paving the way for a systematic onslaught on the sitophobia. With a courage born of confidence, he must urge these timid and rebellious alimentary tracts to do their duty, and every available aid, medicinal, psychic, and otherwise, must be brought to bear. I have many times assured such patients that if they would eat certain articles I would help them with their digestion, and if I could once get them to take the supposed risk and no harm arose, the victory was won. In exceptional instances strategy is justified in getting some feared article ingested, and afterward pointing out that it had been eaten without discomfort. The physician should be quite sure of his ground, however, before risking this procedure, for breaking the news might result in both indignation and retroactive disgust, defeating the desired end. Some sitophobias, limited to unimportant articles, are best ignored. If the patient is well enough nourished, if other foods in the same class are taken in sufficient quantities to furnish ample calories, and if no special inconvenience is given other members of the family, strenuous efforts to abate such harmless phobias are not justified.

Change of environment, of food, of habits, and of occupation, all exert a helpful influence on fearful and unreasoning appetites. Muscular exercise to the point of fatigue is perhaps the best of all remedial measures in overcoming a sitophobia. Manual labor in the open air, if pushed to the physiological limit, seldom fails to produce a keen hunger. Those who in years gone by earned their bread by physical toil will remember the joy accompanying the arrival of meal time, and will also remember that sharp and comprehensive appetite, relishing everything in sight, and that zest which small deficiencies in food or preparation could not dull. Thus, if we can induce our ill-nourished and timorous patients to enter into a complete change of habits and diet, so that as far as practicable muscular effort may take the place of sorrowful meditation; that live, outward interests may banish morbid introspection; that real, bodily fatigue may replace microscopic self-analysis, then may we confidently anticipate a healthy desire for those articles of food demanded by a normal body, a desire whose cheerful and harmless indulgence will effectually dispel the doubts and apprehensions of that digestive imp, sitophobia.

Biological Effects of Radio-Active Thorium

By Our Berlin Correspondent.

The experiments so far made on the biological effects of radio-active substances have given rather contradictory results, in so far as some experimenters find a stimulating and others a destructive action on animal and vegetable life.

This apparent contradiction has now been eliminated by the interesting experiments described below, the importance of which cannot possibly be overrated.

Whereas radium is a most expensive substance, available only in minute quantities, thorium is an incomparably more plentiful element and accordingly allows radio-active phenomena to be investigated on a large scale and without any considerable outlay.

Dr. W. von Bolton therefore uses this substance for studying the biological effects of radio-active matter on lower and higher organisms. In a first experiment, he succeeds in producing by the action of thorium a most luxuriant vegetation of bacteria, the vitality of which however is rapidly exhausted. In fact, this element, after stimulating vegetable growth, soon destroys it by more prolonged action.

Dr. von Bolton has also investigated the effects of thorium on animal life, notably on a small fish known as *amphioxus lanceolatus*, which is the most rudimentary vertebrate animal in existence. Having introduced a certain number of individuals into glass jars, each containing 2 liters of sea-water and 200 grains of boiled sea sand, with or without a variable percentage of thorium, he compares the life of the fish in these different jars. Each of these is traversed by a continuous current of air bubbles, and any evaporated water is replaced by distilled water.

It was found that the fishes presently dug themselves into the sand in a condition of apathy. In order to ascertain whether they are still alive, the experimenter sent an electric current through the water for 2 to 3 seconds, when those living soon begin to move about.

Whereas the specimens in the jars containing only sand and water were found to be completely decayed after five weeks, while the walls of the vessel were coated with a luxuriant growth of algæ, the vessel containing 12 per cent of thorium still contained 10 per cent of living fishes after three months, but a far less plentiful growth of algæ. In the third vessel, containing 25 per cent of thorium, as many as 30 per cent of the amphioxus were found to be alive, whereas the wall only showed traces of algæ, and the fourth vessel, with 50 per cent thorium, even after 7 months, contained 90 per cent of living fishes, with only slight traces of algæ on the walls. These phenomena are far less striking in vessels containing thorium oxide, in the place of metallic thorium.

As thorium, especially in a metallic condition, thus stimulates at first and then destroys vegetable life whereas animal life only undergoes a positive, stimulating influence—it must be possible by means of thorium to kill bacterial growth in an animal body without affecting the latter. This opens up new vistas for the medical applications of radio-active matter.

The destructive effects of thorium on vegetable life are confirmed by an experiment on grass, growing in earth with a variable percentage of thorium.

Electric Heating in Norway

A new power house, utilizing the water power of the Sagefoss, has recently been inaugurated at Flekkefjord, Norway. Part of the electrical energy supplied by this plant is to be used in connection with systematical experiments on electric heating by means of surplus energy in Swedish tile or fayence stoves. This is thus the same system as at present tested in Gottenburg, where the stoves heated over night will keep their heat for ten to twelve hours.

In the present case, the utilization of electricity for heating is greatly facilitated, as there is also some surplus energy available during part of the day. Electricity is, in fact, used at Flekkefjord on a large scale for cooking, and this amount of energy is available during the rest of the time for heating purposes.

Making Ice With Heat

Refrigeration Without Power for Home Use

By Frank C. Perkins

A UNIQUE and interesting type of automatic iceless refrigerator of English design for use in residences and hotels, is shown in the accompanying diagrams, Figs. 3, 4 and 5 and in illustration Fig. 1, the former showing the details of construction and method of operation in using electricity, gas or oil for supplying the necessary heat.

A jungle type of ice maker pictured in Fig. 2, has been designed especially for the use of tropical expeditions. It makes 7 to 10 pounds of ice in two to three hours and is operated by an oil burner or wood fire, and is portable and absolutely "fool-proof."

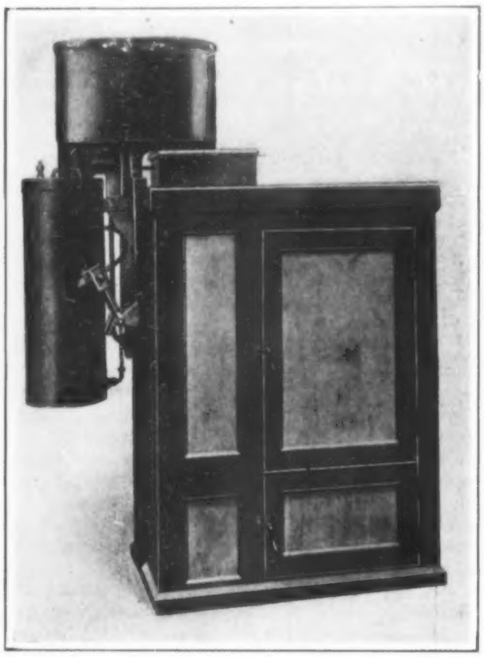


Fig. 1.—Iceless Portable Refrigerator for the Home.

The apparatus during its heat stage has an oil burner under the generator, while during the cooling stage, the burner is removed and a cooling tank and insulated ice mold are in position. One type of this apparatus has an insulated brine tank for ice making. Its capacity is from 1 to 1½ hundredweight per twenty-four hours according to external conditions, gas or electricity supplying the heat.

The illustration Fig. 1 shows the vertical type of self-contained semi-automatic refrigerator and cabinet for country houses. The cooling power of the apparatus is equal to that of about 2 hundredweight of ice per twenty-four hours. The paneled tank cabinet measures approximately four feet by three feet and five feet high and it is lined with marble and fitted with marble shelves and solid nickel ice mold. The walls are insulated and about six inches thick and the available capacity is about 23 cubic feet. An automatic switch cuts off the current instead of a gas valve where electric current is used.

One of the large self-contained English refrigerating equipment is provided with a small room having a cooling power equal to that of about five hundredweights of ice per twenty-four hours. The dimensions of the apparatus are 4 feet by 3 feet 8 inches by 3 feet 2 inches high, and the room measures 5 feet by 4 feet by 6 feet high over all.

Where hotels have their own electric light plant either electricity or steam can be used for supplying the necessary heat for operating this refrigerator.

There is no doubt that a refrigerator which would require no ice, salt, chemicals, skilled attention, repairs, renewals or recharging would be a boon to the housewife and to the hotel manager. There is no question but that a simple appliance for artificially producing cold for a variety of purposes is a growing necessity. There are many refrigerating machines on the market, and for use in very large cold storage or ice-making installations, where skilled engineers are always in attendance, these machines have been found eminently suitable; but where such skilled attention is not available, they are certain to get out of order sooner or later. For this reason, and because they all require some form of motive power, they have not found great favor with those requiring cold only on a moderate or small scale. It is for this class of users that the new iceless refrigerator was specially designed.

The refrigerator is constructed in various sizes for making from a few pounds of ice up to one ton per day, or for cooling from 1 to 10,000 cubic feet of storage space without motive power and without skilled attention. It is operated by the direct application of heat from any available source, such as gas, steam, oil, wood, coal or electricity. Such is the simplicity of the principle that no running machinery, glands, or regulating valves are employed and as there are no moving parts to wear or get out of order, no repairs are required.

The apparatus is noiseless and vibrationless. It is constructed to maintain any required temperature, down to many degrees below freezing point, according to requirements specified when the apparatus is ordered. It can be adapted for any purpose requiring low temperatures and among the common uses to which it is put are, the cooling of safes, rooms and stores and cold storage for freezing meat, poultry, game and fish; also for making ices or ice cream and water cooling. The equipment is of great value in cooling milk, cream, butter and other perishable provisions, as well as for drying air by freezing out the moisture.

The refrigerator is operated on what is commonly known as the "Ammonia Absorption" principle, and differs from all others in the fact that it is hermetically sealed.

Diagram Fig. 3 shows that the essential parts of the machine comprise a combined absorber and generator (or still), a condenser, and a receiver. The generator *A*, which contains a strong mixture of ammonia and water, is heated by a gas burner *B*, electric heating wires on bottom of generator or other suitable means. The ammonia is thereby distilled and passing through the pipe *C*, which is surrounded by water in the tank *T*, it is cooled and condensed. The resulting liquid (pure anhydrous ammonia) runs by gravity into the receiver *R*. This process is continued until all the available ammonia has been distilled and collected in the receiver. At this state there is left in the generator a hot and very weak liquor (practically pure water). The generator is then cooled by admitting cold water to the jacket *J*. This creates a partial vacuum, causing the anhydrous ammonia to evaporate very rapidly. At the same time the weak liquor is cooled and becomes

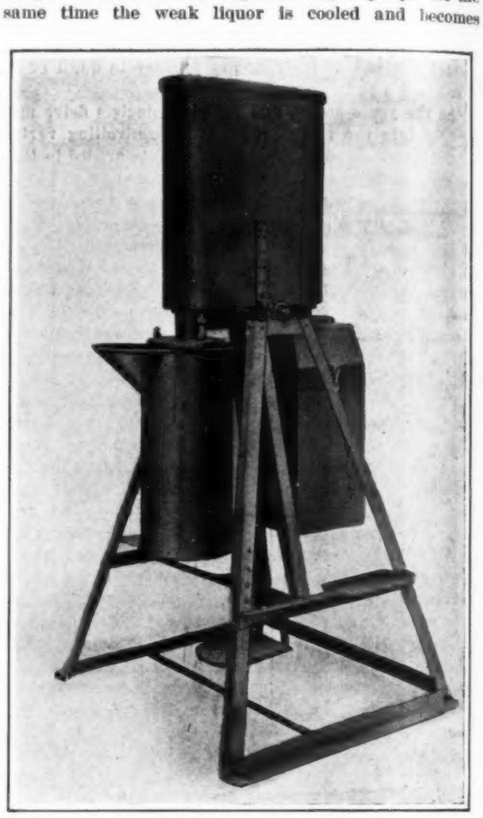


Fig. 2.—A Simple Portable Absorption Ice-making Machine for Tropical Expeditions.

"greedy" for ammonia. It therefore absorbs the vapor resulting from the evaporation of the liquid in the receiver as quickly as it is formed.

The evaporation of the ammonia in the receiver continues until the whole of the liquid has evaporated and been re-absorbed by the liquor in the absorber (the vessel which previously acted as the generator). The liquid in evaporating takes up a large amount of latent heat and consequently the receiver becomes intensely cold and cools all surrounding objects.

When all the liquid has evaporated from the receiver the same state of affairs exists in the apparatus as before the heating was begun. The process can therefore be started again and the same cycle of operations can be repeated an unlimited number of times. The ammonia is not altered or weakened by the process and as there is no possibility of escape, the same charge of liquor will last indefinitely.

To increase the evaporation surface and hasten the evaporation, the receiver often has a coil of pipe connected with it. In many cases this coil is immersed in a tank of brine or other non-freezing solution as noted in diagram Fig. 4. This brine acts as a store for a large quantity of cold and maintains a uniform temperature during times when the apparatus is not being worked.

From these drawings it will be seen that the machine is operated by alternately heating and cooling the vessel *A* (Fig. 4) which acts alternately as a generator and an absorber. There is an automatic electric

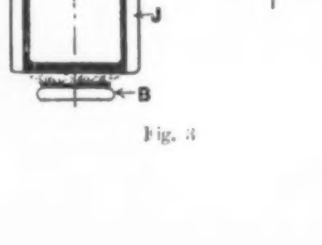


Fig. 3

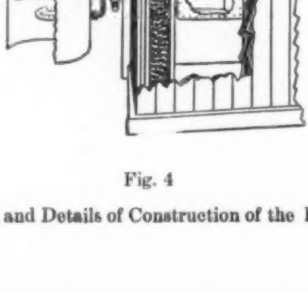


Fig. 4

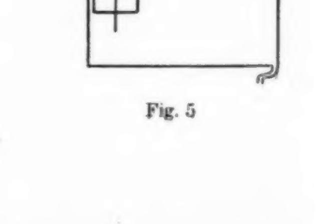


Fig. 5

Principle of Operation and Details of Construction of the Iceless Refrigerator.

switch or gas valve device for turning off the heat and admitting water to the cooling jacket. The tube *K* is filled with water and sealed. The curved portion is flattened. The straight end of it dips into the well *L*, which is surrounded by the liquid in *A*. As the temperature of the latter rises, the water in the tube *K*, becomes heated and expands. Owing to this expansion the curved part of the tube tends to straighten out more and more as the temperature rises. At the end of the tube is a catch *M*, against which rests the weighted lever *N*. The catch is so adjusted that at the required temperature the lever is released and falls.

The lever is connected with the electric switch or gas tap and a three-way water cock, and when it falls, it either breaks the electric circuit or turns out the gas, leaving only a small pilot light burning, and admits water through pipe *O*, from the tank *D* to the jacket *H*. The water fills the jacket and overflows through the spout *P*, and is either carried away to waste or collected in a tank for future use. The lever of the water in *D* is maintained by the ball-cock *S*, connected to the water supply.

When the semi-automatic machine is employed the apparatus is re-started by raising the lever *N*, which turns on the gas or electric current and cuts off the water supply from tank *D*, to jacket *H*, and drains the last. There is no communication between the well *L*, and the generator *A*. When other sources of heat than gas are used, the arrangement is modified but is substantially the same. The machine is semi-automatic and the heating has to be started by hand each time.

A completely automatic device is shown in diagram Fig. 5. This refrigerator will go on working without attention so long as the water is running. Part of the water overflowing from the condenser is allowed to run into the tipping tank *T*, pivoted at *P*. When this tank receives a certain volume, it overbalances and pours its contents into the bucket *B*, which drops and operates the water and gas cock *W* or electric switch.

The tipping tank when empty immediately returns to its normal position. In the bucket *B*, is a small hole so that while the tipping tank is refilling, the bucket empties itself and the counterweight *X* raises it into position again. The electric switch or gas cock is fitted with a ratchet and pawl device so that the rising of the bucket does not affect the cock or switch. One stroke of the bucket turns the gas or electric current off and the water on, and the next turns the gas or electric current on and the water off, and the gas relights from a small by-pass.

The flow of water into the tipping tank is so adjusted that the tank fills up to the necessary level to overbalance it in the same length of time as is required for heating or cooling the generator. This automatic gear can be placed in any convenient position.

The water required for operating the machine is not contaminated in any way but is slightly warmed; therefore in cases where the cost of water is an item for consideration, it can be collected in a tank and used for other purposes after having passed through the machine. Where boilers are installed, this water can be used economically as feed water the refrigerator acting as a feed water heater. If desired, the same quantity of water can be used over and over again for this apparatus.

The cost of operating the machine is very low. The actual working cost largely depends, of course, on the source of heat available. For small apparatus, gas is the most frequently used, it will therefore be well to give an example of the cost of operation by this means.

A small iceless refrigerator providing cooling power equal to that of a hundredweight of ice, consumes about 250 cubic feet of gas. Thus, where gas costs two shillings and six-pence (62 cents) per 1,000 cubic feet, a small machine provides cooling power at a cost equivalent to buying ice at 15 cents per hundredweight delivered.

The larger the refrigerator the more economical is the working. Where steam at a pressure of not less than 50 pounds per square inch is available, the cost of working the machine is so trifling as to be almost negligible. With an efficient boiler, cold equivalent to the melting of half a ton of ice can be produced per hundredweight of coal consumed.

In any room cooled by this machine, the air is kept perfectly dry and the damp mustiness which is inseparable from ice-cooled chambers is entirely avoided. It is this dampness which causes meat and other articles of food to deteriorate, lose their flavor and become unfit for use in a very short time.

In case the machine is required for ice making only, it is fitted to an insulated tank containing some non-freezing solution such as strong brine. The machine keeps this 10 deg. to 20 deg. Fahr. below freezing point and in it are placed cans with the water to be frozen.

Blocks of ice can be made of any desired shape or size, and if distilled water is used, perfectly clear ice can be produced. If the water is not distilled, minute bubbles of air contained in the water are frozen into the ice and give it a white, opaque appearance.

For use in making ice cream, an ordinary ice cream freezer is immersed in an insulated tank containing brine which is kept at 10 deg. to 15 deg. Fahr. below freezing point by means of this machine.

It is of great value for use in the dairy, as, to keep milk perfectly fresh it should be cooled to between 35 deg. and 40 deg. Fahr. either immediately that it comes from the farm or after pasteurization. Artificial cooling is absolutely necessary in order to prevent milk from turning sour in hot weather.

For this purpose the machine is of the greatest possible importance. In most cases the milk is first passed over a cooler or "refrigerator" through which cold water is allowed to run. This reduces the temperature to between 60 deg. and 70 deg. Fahr. The milk is then passed over another refrigerator, through which brine at 20 deg. to 30 deg. Fahr. is circulated, reducing the temperature of the milk to about 35 deg. Fahr.

The brine is stored in an insulated tank and is kept cool by the machine. It is circulated through the refrigerator by means of a small pump. Where a plentiful supply of water is not available the whole of the cooling can be done with the brine. In many cases it is desirable to store the cooled milk in a cold room and when this is required the installation is so arranged that the brine tank is situated in the storage room and keeps it at a low temperature.

The most economical method of operating the machine is by a steam coil, and as most dairies are fitted with steam boilers, the installation of the machine provides means of cooling milk efficiently, cheaply and in by far the most simple and cleanly manner.

Air can be dried by being passed over a cold surface which causes the moisture to condense. Thus, if damp air is drawn or forced over a coil of refrigerating pipe, the moisture is deposited on the pipe and either drips off into a suitable receptacle or forms a layer of frost on the pipe, leaving the air perfectly dry.

On the Devitrification of Silica Glass*

By Heat and by Radium Rays.

By Sir William Crookes, O.M., For.Sec.R.S.

THE use of apparatus blown and worked from melted quartz is now almost universal in chemical laboratories, especially where temperatures are required above the heat at which glass softens.

When working at fairly high temperatures I was inconvenienced by the leakage of air through silica glass.[1] The apparatus (Fig. 1) was in the form of a perfectly clear and transparent tube, 1 centimeter diameter and 20 centimeters long, with a bulb 2½ centimeters diameter blown on the end. The other end of the silica tube was drawn out for connecting with the pump and sealing. It was exhausted to a high vacuum and heated to near redness along its whole length to remove any gas that might be condensed on the walls—it was then sealed off.

The tube was placed bulb uppermost in an electric resistance furnace in such a position that the bulb would be at the point of greatest heat, the lower part of the tube remaining comparatively cool; it was kept at a temperature of 1,300 degrees for twenty hours, at the end of which time the silica tube was removed from the furnace. The long continued high temperature caused the bulb and the upper part of the tube to devitrify, and become white and translucent like frosted glass. The sealed-off end was carefully opened, and it was apparent that the inrush of air was by no means so strong as it would have been had the vacuum been as perfect as it was when the tube was sealed up.

This looked as if there had been a considerable amount of leakage through the devitrified bulb, and I tried a test experiment. The tube was again attached to the Sprengel pump, and exhausted to as high a point as possible. During the progress of exhaustion, when the pump was rattling with the characteristic sound of a high vacuum, a large and powerful Bunsen flame was used to heat the bulb. Not the least difference in the sound could be distinguished. When the vacuum was at its highest the tube was sealed off, it was put into the electric furnace, and kept at a temperature of 1,300 degrees for eleven hours. After cooling the end of the tube was broken off under mercury. The mercury rose, but did not fill the bulb. The amount that entered was measured, and found to be 17.75 centimeters. Afterward the tube and bulb were completely filled with mercury, the whole again measured, and the capacity of tube and bulb was found to be 19.25 centimeters, showing that 1.5 centimeters of gas, or 7.79 per cent of the tube's capacity, had leaked through the devitrified silica in eleven hours at 1,300 degrees.

To ascertain if air would leak through the devitrified silica at the ordinary temperature a fac-simile of tube and bulb was made in glass, and the two tubes were simultaneously exhausted on the pump. They were both heated, allowed to cool, and sealed off at the same time. The silica and glass tubes were put in the balance case and kept there for some time. When they were both at uniform temperature the silica tube was weighed. The tube and weights not being moved in the meantime, weighings were taken hourly, the balance being untouched during the intervals. In eighteen hours the weight increased 0.048 grain.

After the silica and glass tubes had been at rest for some days they were opened simultaneously under mercury. The glass tube filled at once, only a microscopic bubble of air remained at the top. The silica tube, on the contrary, only partially filled, and on measuring the mercury that entered it amounted to 10.15 centimeters, the capacity of the tube being 19 centimeters. Therefore in a few days air to the amount of 46.58 per cent of the total capacity of the apparatus had leaked in.

A micro-photograph was taken of the surface of the devitrified silica bulb (Fig. 2). It showed a surface cracked all over into the appearance of cells, and on closer examination many of the cells showed decided hexagonal outline.

I observed a similar appearance a few years ago when a silica dish, originally clear and transparent as glass, was used for evaporating down about 100 milligrammes of pure radium bromide. Patches appeared on the bottom having a dull roughened appearance, and on examination under the microscope the appearance was very similar to the surface of the devitrified silica bulb just described (Fig. 3). The appearances are so alike that it is legitimate to assume that the same cause had been at work, and that devitrification of the surface is produced both by exposure to a very high and long continued temperature and to the contact with a radium salt at a temperature of boiling water. I have not seen this effect on the surface of glass or silica bottles in which radium salts have been kept in the cold for some years.

Fig. 1.—Silica Glass Tube which Showed Leakage on Heating.

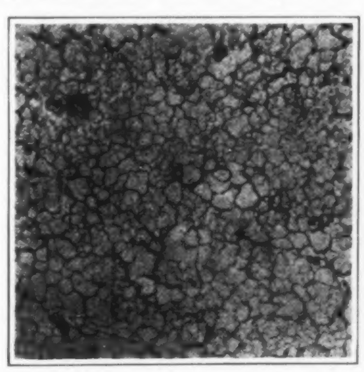


Fig. 2.—Devitrification of Silica Glass Produced by Heat (Microphotograph).

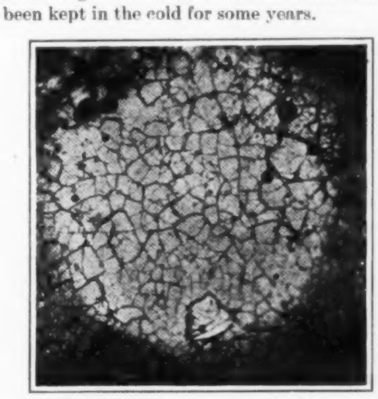


Fig. 3.—Devitrification of Silica Glass Produced by Radium at Boiling Temperature.

* A paper read before the Royal Society, March 7, 1912, and published in *The Chemical News*.

[1] Jaquerod and Perrot have shown that fused silica is permeable to helium and hydrogen at a low red heat. (*Comptes Rendus*, cxxxix., 789, Nov., 1904; and cxliv., 135, Jan., 1907).

The United States Patent System—I*

Its Good Points and Its Faults

By Robert N. Kenyon

It will be generally conceded, I believe, that the framers of our Constitution showed a far-sighted wisdom in providing in that instrument that Congress should have power to grant to inventors for a limited time an exclusive right to their inventions, and that the Patent System which has been created under that provision has contributed in large measure, and probably more than any other single factor, to the marvelous mechanical and industrial progress that has been made in this country in the last century and notably in the last forty years. Whatever defects may be found in our Patent Laws, and however severe the criticism of them may be at the present time, we should not forget that these laws have as a net result conferred great benefits upon the people of this country. The American is endowed with the inventive talent in a high degree and this talent has been tremendously stimulated by the rewards which the Patent Laws have offered. In the field of invention the United States leads the world, and no sufficient explanation of this superiority can be found except in the more complete and efficient development of its Patent System and the greater liberality which it has shown to its inventors. No more striking proof of this can be adduced than the fact that the other nations of the world which are the most progressive have, in recent years, been changing their systems to make them conform more nearly to our own. A great army of inventors has been developed in this country who are working constantly to improve every human contrivance that man employs in his daily work and life. Many of these men have come from the humbler and poorer classes, and the pecuniary rewards which their inventive work has secured under the law have far exceeded anything they would have won by other means. When a system has contributed so largely to the public good, it is the part of wisdom to proceed cautiously in modifying it.

Yet it must be admitted that there are serious defects in our Patent Laws and their administration, defects which have become more apparent and have been more seriously felt in recent years. The inventor complains of the law's delay in granting and enforcing his rights, of the intricacy and vexation of the proceedings in the Patent Office, and the Courts, of the heavy burden of expense involved in such proceedings, of the undue advantage enjoyed by the rich and powerful corporation, and of the inadequate recoveries granted by the Courts even after patents have been sustained and infringement decreed. On the side of the public it is claimed that many patents have been granted that should not have been granted, and that an unjust burden of litigation has thus been thrown upon many innocent manufacturers and dealers tending to hamper and check legitimate industry. It is also charged that patents have been used as an instrument in the hands of unscrupulous parties and corporations to create or promote unlawful monopolies, extending to unpatented articles. The general sentiment against monopolies has become so strong and aggressive that it has extended even to our Patent System, and has created a feeling of hostility toward it which is not deserved, but which is threatening dangerous innovations.

In the present state of the public mind, and in view of the conditions I have referred to, it seems certain that the Patent Laws must and will be amended within the near future. It is my purpose to point out some changes in the law and the practice which I believe would be beneficial. I shall consider first the subject of Court Procedure.

PROCEDURE IN THE COURTS.

It has been said that when an inventor secures a United States Patent, he is getting nothing more than a license to bring suit. In a sense this is true. The Government does not guarantee the validity of a patent. It does not assume the task of the responsibility of preventing infringements. When an infringement occurs, the inventor or his assignee must bring a suit, and in this suit all questions of novelty, and patentability, and the like, are open, and must be considered by the Court, if presented by the defense.

The inventor may bring a suit in equity or an action at law, as he sees fit, but as nearly all of such suits are on the equity side of the Court, I shall confine my attention to a discussion of the procedure in such equity cases.

An equity suit is begun by the filing of a Bill of Complaint in which the complainant sets out his case. The defendant has about two months thereafter in which to appear and answer or otherwise plead. The complainant then has from one to two months in which to reply to the answer or take other suitable action thereon. The result of this procedure in ordinary cases is to give to the parties about three or four months after the commencement of the suit for the completion of the pleadings and the settlement of the issues, and the preparation of their proofs. This is not an unreasonable amount of time. The chief defenses in a patent suit are generally based upon the prior art, consisting of prior patents and publications, United States and foreign, and prior uses in this country. A thorough investigation of such defenses ordinarily involves a large amount of work, and the time allowed a defendant for this purpose is none too great. Indeed in many cases a longer period of time may be required, and the Court is empowered to grant such additional time or to allow a subsequent amendment of the answer.

When the pleadings have been filed, the next step is the taking of the testimony. Section 862 of the U. S. Revised Statutes provides that the mode of proof in equity causes shall be according to rules prescribed by the Supreme Court except as otherwise specially provided in the statutes. Rule 67 of the Equity Rules formulated by the Supreme Court provides among other things that the testimony in equity causes shall be taken before one of the examiners of the court, or before an examiner to be especially appointed. This rule was not drawn with special reference to patent cases but applies to all suits in equity; but nearly all patent litigation, being brought in equity, is governed by its provisions. When the testimony is finished, each party prints his own evidence, or pays the clerk of the court for printing it, and the case is then argued before a judge upon this printed record.

This method of taking the evidence is open to serious criticism, and is the feature of the present practice which is most generally condemned.

It is a slow and tedious method of presenting proofs especially in patent causes. It is an unfortunate fact that under this practice, patent cases generally drag along for two or three years or even longer, after the filing of the bill, before they are ready for argument. This often amounts to a denial of justice. During all this time, if no preliminary injunction has been granted (and such injunctions are rarely secured) the infringement is continuing, the complainant's business is being injured, perhaps irreparably, and the defendant is reaping profits which, by reason of the technicality of the law of recoveries, he is seldom decreed to pay over to the complainant. In the famous Selden case, the first suit was brought in 1900. This was settled in 1903. A second suit was brought in 1903 against the Ford Motor Company. The taking of testimony in this case lasted for the extraordinary period of about five years, and the case was not argued until May, 1909. Meanwhile the complainant was being unjustly deprived of its monopoly, if the patent were valid and broad in scope, as the lower court held it to be. The swarm of infringers were enjoying through all these years an illegal profit, if the patent were in fact valid and broad. The manufacturer who did not wish to infringe upon a legal monopoly was left in the dark for years; he did not know what his rights were. If he manufactured he did so at his peril. Clearly it was to the interest of the complainant company, if its patent was valid and broad, to have an early adjudication of its rights; and, if the patent was invalid or narrow, as it was afterward held to be by the Court of Appeals, it was clearly to the interest of the public that a prompt decision should remove this cloud upon their business. But there was a great volume of testimony to be taken, and under the present method almost five years were consumed in taking it. If the case had been tried in open court, it would probably have been disposed of in a small fraction of this time.

The present practice also opens the door to great abuses in the offering of testimony that is irrelevant or immaterial or incompetent. Rule 67 provides that the examiner shall not have power to decide on the competency, materiality, or relevancy of the questions. He is a mere transcribing officer. When a question is asked he must write it down, no matter what it may be, and the witness must answer it. It may be on a subject, not having the slightest bearing on the issues of the case, or the facts testified to by the witness on his direct examination; it may be foolish, or impertinent, or insulting, or even indecent, but the witness must answer it, and the answer be put down, unless the witness claims that an answer might incriminate or degrade him, or takes the matter in his own hands, and either of his own will, or under the advice of counsel (which some courts have held that counsel has no right to give), declares in righteous anger that he will not answer the question, the Supreme Court of the United States to the contrary notwithstanding, unless the court before whose examiner he is testifying, enters a special order commanding him to do so. Where a witness flies in the face of the rule, though he may be more than justified in his position, his whole deposition may nevertheless be struck from the record. The result is, particularly in patent cases, that the record is often inexcusably expanded. Pages upon pages of testimony are introduced which would never be admitted and probably never offered were the case being tried in open court. In the Selden case the record, when printed, comprised more than a dozen volumes, each of large size. In open court this would have been reduced to a small fraction of that size. And what is true of this case is true of most patent cases in a considerable degree.

It results from all this that patent litigation is exceedingly expensive. The cost is prohibitive for the man of small means. The examiner's fees are regulated by statute at so much per session and a certain amount per folio for the original and an additional charge for each copy. These fees are taxable against the defeated party. With records unnecessarily expanded, the examiner's bills often amount to thousands of dollars, and when counsel fees, at so much per day, are added, the bill is one that only the rich man or the rich corporation can afford to pay. When the testimony is finished, it must be printed at an expense of nearly a dollar a page, and this adds another large item to the cost. It is no wonder that many inventors have preferred to sell their valuable inventions to a wealthy corporation for a wholly inadequate price rather than to assume the great financial burden of a patent suit.

How can these defects in the administration of the Patent Law be remedied? It seems clear that the first thing that ought to be done is to change the procedure so as to provide that the testimony in patent causes, or as much of it as possible, shall be taken in open court before the judge who is to decide the case, just as in actions at law, the testimony is taken before the jury. This would greatly expedite the trial of such suits, and would go far toward preventing the present vexatious and burdensome delays. The record would be confined to proper evidence, for the Court would rule upon the questions as they are asked, and would exclude testimony that is improper under the established rules of evidence. The judge would see the witnesses himself, and would thus be better able to determine their honesty and credibility, and the weight which should be given to their testimony. He would understand the case as it progressed, and would have a much better grasp of the difficult mechanical and scientific questions involved than he could possibly obtain from the mere reading of printed depositions. Moreover, he would have the great advantage of being able to ask questions himself, whenever the testimony of a witness was obscure or doubtful in meaning. This would be particularly helpful in connection with the examination of experts. It is obvious that if the Court could hear an expert testify and could call upon him to explain any doubtful point, when the doubt arose, or to supply any omission that might occur in his evidence, or to explain the meaning of terms in the art, the Court would certainly obtain a better knowledge of the subject-matter and the issues involved than is possible under the present practice.

And the mental attitude of the expert himself would be different. At present the giving of expert depositions in patent suits is too much like a war of words or wits between the witness and cross-examining counsel in which the witness is seeking to present and marshal the facts favorable to his own side of the case and to belittle or pass lightly over the facts that are unfavorable. The present practice tends to develop the habit of evading and of giving irresponsive and argumentative answers. If an expert testified in open court, his testimony would certainly be more direct and frank, for the judge would be there to insist upon fair and responsive answers, and the expert would know that the weight to be attached to his evidence would depend largely upon the manner in which he testified. Expert evidence would be greatly shortened and clarified, and the Court would have less difficulty in determining whom to believe. In such an examination of witnesses in open court, cross-examination would be limited within a reasonable scope, thus causing a material saving in time, labor and expense.

This procedure is followed to-day in the trial of patent causes in England. In a letter which I have recently received from one of the best known firms of chartered patent agents in London, they say, in speaking of this subject:

"The practice in the English courts is eminently satisfactory; there is a remarkable absence of red tape, the proceedings are expeditious and the courts take a broad view, and give their judgments on matters of real substance."

In commenting on the English practice of examining experts in open court, they say:

* Paper read before the American Institute of Chemical Engineers at Washington, December 22, 1911.

"The examination of experts is not long drawn out in the majority of cases, for the questions and answers are short and snappy rather than diffuse and calculated. As the whole evidence is taken in the open court the proceeding resolves itself into a dialogue between counsel and experts during which the judge is enabled to grasp all the essential facts without putting more than an occasional question of his own."

A plan has been suggested for the improvement of our present procedure which commends itself to my judgment, and which resembles in some respects the present chancery practice in the High Court of Justice in England. It is substantially as follows. When the pleadings have been filed the complainant shall within a certain time give notice to the defendant that he will apply to the court for certain directions as to the taking of testimony and other matters, specifying what directions he will ask for. The defendant shall have a certain time thereafter within which to serve upon the complainant a notice of the directions which the defendant will ask the Court to make on his behalf. The parties shall, at the appointed time, appear before a judge of the Court to have these directions settled and ordered. Complainant's counsel shall state to the Court briefly the nature of his case, and in general what testimony he desires to take, and shall ask for any special orders he may desire for commissions, or examination of witnesses before trial or *de bene esse*, or production of documents, or inspection of property or for other purposes. Defendant's counsel shall then make a similar statement in relation to the defenses, and ask for such special orders as he may desire. The Court shall then make suitable directions and orders, on all these matters, determining among other things what testimony, if any, shall be taken out of Court and how and by whom it shall be taken, and allotting times for that purpose. It shall set a time for the trial at which the parties shall present their proofs in open court, except such evidence as may have been ordered to be taken before trial. The Court should have power in its discretion to adjourn the trial for a short time after complainant's opening case has been presented to allow the defendant to further prepare his case and this practice should be followed in patent causes whenever the nature of the subject-matter is so difficult that in the judgment of the Court defendant is entitled to such additional time to prevent surprise or injustice, for it is sometimes true that the defendant is not advised as to the complainant's theories until the complainant has presented his opening proofs, and in such cases defendant should be given some time to consider these theories with his expert. Thereafter the trial should be resumed, and defendant required to produce his testimony in open court except as otherwise previously ordered. Then a further short adjournment might be taken to permit the complainant to consider defendant's theories and prepare to meet them, if the Court considered that the complainant was fairly entitled to such additional time. Then the trial should be resumed and the complainant's rebuttal evidence taken in open court except as otherwise ordered. The case could then be argued by counsel, after which a reasonable time could be allowed for the filing of briefs. I believe that this procedure, thus merely outlined, would bring patent litigation within reasonable limits as to time, labor and expense, and would promote justice both to the inventor and the public.

There is a certain kind of testimony quite common in patent causes which has to be taken before trial. I refer to testimony particularly in support of prior uses given by witnesses who live so far from the place of trial that they are beyond the reach of the subpoena. The statutes provide that such testimony can be taken before a notary or other proper officer in the form of depositions *de bene esse*. This practice must, of course, be preserved. It would be advisable, also, to amend Rule 67 so as to give the Court in one district power to appoint special examiners to take testimony in any other district in the country.

All these matters could be definitely settled when the parties come before the Court for directions as above suggested. If further directions were needed at any time during the progress of the case, the parties could be brought before the Court on suitable notice by either side and application made for such further order. All motions and applications in a particular case should be made to the same judge and the case should be tried by him. This judge would quickly become familiar with the nature of the suit and would be in close touch with it, and could thus see that no undue delay was permitted.

One cause of error in the trial of patent suits grows out of the fact that these suits involve mechanical, chemical or other scientific questions, which are often exceedingly technical and subtle, and yet these questions have to be determined by judges most of whom, though learned in the law, have had no mechanical or scientific training. Questions in mechanics and chemistry which would be puzzling to a trained engineer or chemist, must be decided by a judge who has never had any education or training in those subjects. He is compelled to rely upon the evidence of the experts for guidance. But the very terms in which the experts speak may be almost as strange to him as the words of an unknown language. We would not expect a chemical engineer, no matter how distinguished he might be in his calling, to satisfactorily decide questions of law. Yet we do expect lawyers who sit upon the bench as judges to pass upon equally difficult questions of chemistry. It is not surprising that the courts now and then fall into serious scientific error. It is surprising that such errors do not occur more frequently.

In a recent decision in the case of *Parke-Davis Company vs. Mulford Company*, 189, Fed. Rep., 115, Judge Hand says:

"I cannot stop without calling attention to the extraordinary condition of the law which makes it possible for a man without any knowledge of even the rudiments of chemistry to pass upon such questions as these. The inordinate expense of time is the least of the resulting evils, for only a trained chemist is really capable of passing upon such facts, e. g., in this case the chemical character of Von Furth's so-called 'zinc compound,' or the presence of inactive organic substance. In Germany, where the national spirit eagerly seeks for all the assistance it can get from the whole range of human knowledge, they do quite differently. The court summons technical judges to whom technical questions are submitted and who can intelligently pass upon the issues without blindly grouping among testimony upon matters wholly out of their ken. How long we shall continue to blunder along without the aid of unpartisan and authoritative scientific assistance in the administration of justice, no one knows; but all fair persons not conventionalized by provincial legal habits of mind ought, I should think, to unite to effect some such advance."

It has been suggested that one remedy for this evil would be to empower the Court to call upon some impartial expert to advise with it on the scientific side of the case. This is now the practice in Germany. There the Court usually summons some expert of its own choice to instruct it upon the mechanical and scientific issues. It may also call upon the Patent Office for an opinion. Either side may challenge the expert on the ground that he is prejudiced or has already given an opinion upon the questions at issue.

It must be admitted, however, that there are serious objections to such a plan. It would be easy to secure an honest expert but it would be difficult to find a truly impartial one. The more learned an expert is the more likely he is to have some previous knowledge of the very questions in issue, and to have formed a previous judgment more or less complete upon those issues. No matter how conscientious he is, he is likely to approach the subject with some preliminary bias, which may result in great injustice. Such a plan also leads to a division of responsibility between the Judge and the expert.

It would seem wise therefore to go slowly in this matter, and to try first the procedure suggested above of having each side examine its expert in open court where the judge can hear the testimony, and can himself ask questions of the witness. Experience may show that a judge can in this way secure as good an understanding of the subject involved as he could reasonably hope to do from an expert appointed or called in by himself. At all events it is wise to take one step at a time in the case of such a radical innovation.

Another feature of the present system which should certainly be reformed is the practice in the matter of appeals. Prior to 1891 an appeal from a final decree in a patent cause could be taken directly to the Supreme Court of the United States. When that Court rendered its decision, all the issues involved in the case were finally disposed of for the whole country. The decision was binding upon the Circuit Courts all over the land. If the patent was sustained, the owner of the patent could rest secure in the enjoyment of his property, unless some wholly new defense were presented in a subsequent suit; and in such case practically all that the complainant had to do in the later suit was to meet the new defense. The principles and rulings announced in the first decision became the law of the subsequent litigation.

In 1891 the Supreme Court became so burdened with work that it became necessary to find some relief, and for that purpose an Appellate Court was provided in each of the nine circuits, called the United States Circuit Court of Appeals for that circuit. Appeals lay from the Circuit Court to this new Circuit Court of Appeals in nearly all cases, and in many classes of cases, including patent suits, the decision of the Circuit Court of Appeals was final, there being no appeal therefrom to the Supreme Court. This has given rise to an extraordinary condition of things in patent litigation. The exclusive rights granted by a United States patent are certainly valid as to the entire country, and *vice versa*. But under the present system, with its nine courts of last resort in the nine different circuits, a patent may be held good in one circuit and bad in another upon the very same testimony, or may be differently construed.

For example, in the case of *Westinghouse Electric & Manufacturing Company v. Catskill Illuminating & Power Company* 121 Fed. Rep., 831, certain Tesla patents were held invalid by the Court of Appeals for the Second Circuit; in the later case of the same complainant against the Stanley Instrument Company, 133 Fed. Rep., 168, the same patents were held valid by the Court of Appeals for the First Circuit on substantially the same evidence. Again in *Eldred v. Kessler*, 106 Fed. Rep., 509, the patent in suit was narrowly construed by the Court of Appeals for the Seventh Circuit, and the defendant's device held not to infringe. Thereafter in *Eldred v. Kirkland*, 130 Fed. Rep., 342, the same patent was more broadly construed by the Court of Appeals for the Second Circuit, and the defendant's device held to infringe, although it was substantially the same as the defendant's device in the earlier case.

It results from this that litigation upon a patent may be continued interminably and that it is limited only by the financial resources of the parties. When a patent has been sustained by the Court of Appeals in one circuit, the monopoly has been secured in that circuit, but not in the other eight. If infringement is committed in another circuit, the owner of the patent must sue again in the second circuit, and must fight the case all over again and as thoroughly as he fought the first one. While he is likely to prevail in the lower court, because that court presumably will follow the decision of the Court of Appeals in the first case as a matter of comity, he is not sure of prevailing in the higher court, for the new Court of Appeals in the second case is not bound by the decision of the Appellate Court in the first case, and may reach a different conclusion, and hold the patent invalid. On the other hand the patent may be held invalid by the first Court of Appeals, and the public in other circuits may thereby be induced to manufacture, use and sell the article, supposing it to be public property. The owner of the patent could then sue in another circuit, and the Court of Appeals there might hold the patent to be valid. Thus a patent might be held good in four circuits and bad in five, and the result would be a hopeless confusion of rights as between the public and the owner of the patent. And years of litigation would result. This system puts an instrument of oppression in the hands of a wealthy corporation owning a patent, for it might, as a mere matter of business policy, after being beaten in one circuit, continue to sue other parties in other circuits, one after another, until the whole circle of nine had been completed, and the greater part of the public would prefer to submit rather than to incur the cost of defending. The fact that a defeated party may petition the Supreme Court to review the case, does not afford an adequate remedy, because the granting of such petitions is purely a matter of discretion, and statistics show that they are granted in very few cases.

There should be a single Court of Appeals in patent cases. A new court should be created for this purpose to sit in Washington to which all appeals should be taken in patent causes from every circuit. The decision of this court would be final upon all the issues involved, and would be binding upon all the Federal Courts throughout the country, just as the decisions of the Supreme Court were, prior to 1891. A bill to create such a court has been before Congress for some time, and has received the support of the American Bar Association, and, I believe, of a very large portion of the patent practitioners of the country. One great advantage that would result from the creation of such a court, properly constituted, would be that the law would be uniformly construed and administered in all the circuits.

It has been suggested that this appellate jurisdiction in patent causes should be conferred upon the new Court of Commerce. This in my judgment would be a mistake, first, because the judges of this court, though able and learned men, were selected for another purpose, and without any thought as to their qualifications in patent matters, and because, as I am informed, only one of the five has in fact had any experience either as a lawyer or a judge, in the practice or application of the patent law; and, secondly, because the appellate work in patent causes would be so extensive as to require the entire time and attention of the court. Such a court would have a great task and could perform a great public service in building up within the next ten or twenty years a body of decisions under the patent law that would be uniform and consistent, and would enable the public and the bar to know with reasonable certainty what the law is, and to shape their course of action accordingly. The vast amount of property invested in or dependent upon patents is certainly entitled to this recognition and protection, and the public interests require this as a protection against unjust monopoly and oppressive litigation.

It has been suggested that this new court should hear appeals from the highest tribunal of the Patent Office. In my opinion this would be unwise. In *ex parte* cases the primary examiner, if he rejects the application, does so generally upon certain prior patents and publications. He determines for himself what these prior references disclose and how they bear upon the application in question, without the aid of any expert or other testimony. He is presumably an expert himself in that particular art. Upon appeal from his decision, the higher officials of the Patent Offices act upon their own unaided opinions. They are appointed by reason of

their special attainments and qualifications fitting them to pass upon just such technical and scientific questions. If an appeal were then taken to the new Court of Appeals, it in like manner would have to pass upon all the technical questions involved without having any testimony of any kind to guide it or instruct it. Let us assume that it reversed the commissioner and granted the patent, and that thereafter suit was brought upon this patent and the defendant in this suit relied upon the same prior patents and publications that had been cited in the Patent Office as establishing invalidity. The defendant would take the testimony of experts to show that these prior references disclosed the invention in question or that the patent in suit described nothing patentable over them. This testimony might throw such new light upon the situation that the lower court, coming to the consideration of the subject for the first time, might hold that the patent was invalid. But when the case reached the Court of Appeals, the defendant would find himself in a position of great disadvantage. He would be arguing his case before a court that had already decided the very same issues against him on the appeal from the Patent Office. He could urge that the prior decision was made upon an imperfect presentation of the case, upon a record that contained no evidence whatever, and that the testimony now presented for the first time showed that the court had been mistaken in its earlier opinion. But this would place a heavy burden upon the defendant and would be eminently unfair to him. When a court has once decided a question, no matter how imperfect the record, it is strongly inclined thereafter to follow its prior opinion. Judges are human; they do not like to reverse themselves, or to confess previous error. There would be a strong prejudice in favor of their earlier views. The tribunal in this respect would not be impartial. The defendant's case would be in a measure prejudiced against him. No defendant should be compelled to try his case in an appellate tribunal that has previously been required to pass upon the same questions in an earlier proceeding where no testimony could be taken to instruct the court on the scientific questions involved. The injustice of such a procedure is apparent. And a defendant should also be permitted to set up the claims of a rival inventor and to present this question to the court of last resort without being similarly prejudiced by a prior decision of this court between the same two claimants in an interference proceeding originating in the Patent Office.

To be continued.

Reviews of New Books

Die Grundlehren der Höheren Mathematik. (The Elements of Higher Mathematics.) By George Helm, Professor at the Technical University of Dresden, Leipsic; Akademische Verlagsgesellschaft, 1910. 414 pp.

The appearance in recent years of a number of textbooks of mathematics written especially for the student of pure and applied science (physics, chemistry, engineering) may be taken as evidence of the distinct call for this kind of work. The books of Lorenz, Nernst and Schoenflies, Mellor, Perry, and so forth, are each in its own way very excellent. It is rather striking, too, how very dissimilar they are—a fact which is no doubt due to the immensity of the field covered and the practically unlimited possibilities of varying the point of view from which it is surveyed. And the work by Helm before us now is again a distinctly new departure, so that even those who may possess one or more of the existing works of this class will find Helm's book a valuable addition to their book shelf. The author needs no introduction. Perhaps the most characteristic of his productions are his contributions to the general theory of energetics, in which he displays the highest type of originality.

From such an author one naturally expects a book of more than ordinary merit, and a cursory perusal of its pages has proved in no way disappointing, although, of course, as regards the subject matter treated, there is no opportunity for any display of originality, which, in a case like this, can only show itself in the mode of treatment.

The scope and arrangement of the work is best summarized by enumerating some of the principal sub-divisions of the book. The author arranges his matter in twenty-one sections. The first is a general discussion of the mathematical concept of "functions," their classification, representation, etc. The second chapter is devoted to the idea of "limits," leading up to differentiation. The third chapter introduces some applications of differential calculus. The fourth section deals with integration; in the fifth part the idea of vectors and allied matters are introduced. The sixth and seventh sections deal with systems of co-ordinates, treated somewhat in detail. The eighth section is devoted to infinite series, the ninth to relations between three variables, the tenth to the extension to three dimensions of some of the matters treated in the early portions of the book with reference to two dimensions. The eleventh section is devoted to partial differentiation, and the twelfth to multiple integrals. The thirteenth, fourteenth, and fifteenth sections take up various parts of analytical geometry. The sixteenth section is devoted to differential equations; in the seventeenth section integration is taken up in some detail, and the eighteenth section deals in particular with definite integrals. Section XIX is headed "Interpolation." Section XX takes up some special problems of three-dimension analytical geometry, while the last and twenty-first section is devoted to Taylor's series for several variables and applications thereof.

It will be seen from this enumeration that the subject is arranged in somewhat unusual order. The reason for this becomes plain in following the text. The order is determined rather by didactic considerations than by what would appear to be the logical order in a book written purely for reference use in the hands of one who may be assumed to have previously mastered the subject.

Of criticism there is very little to offer. One point, however, the reviewer wishes to take this opportunity of bringing to attention, namely, the unfortunate omission in most books of this kind of all reference to the calculus of variations (if we except the very brief and somewhat unsatisfactory section devoted to this subject in Mellor's book). It is true that the subject presents perhaps more difficulty than the average student in physics and engineering is expected to face, but, on the other hand, the application of the calculus of variations in connection, for example, with Lagrange's equation and Hamilton's principle is so important, that no course in physics can be regarded as complete which does not give the student some working knowledge of these methods. Just because the calculus of variations, taken as a whole, offers considerable difficulties, it is all the more desirable that some competent person should give us some concise statement of the fundamental principles, and just so much of the technique of the calculus as to enable the student who is not in a position to go deeper, to intelligently follow some of the most important applications of this calculus to physical problems. One might express the hope that in a future edition of this work, the author may find it convenient to add a section dealing with this matter. A. J. L.

The History of England. A Study in Political Evolution. By A. F. Pollard, M.A., Litt.D. New York: Henry Holt & Co., 1912. 16mo.; 256 pp. Price, 50 cents net; postage, 6 cents.

Peoples and Problems of India. By Sir T. W. Holderness, K.C.S.I. New York: Henry Holt & Co., 1911. 16mo.; 256 pp. Price, 50 cents net; postage, 6 cents.

History has so long been regarded as peculiarly a narrative of courts and kings that it is refreshing and wholesomely educational to find it dealt with as a story of human hearts and impulses. Prof. Pollard writes from the distinctly modern viewpoint, and his interpretation of the old runes of history into the living language of to-day is a commendable handling and condensation of England's emergence from feudalism, her progress in nationalism, her expansion and industrial revolution, and her century of supremacy as the heart of an empire.

"Peoples and Problems of India" makes a good companion volume to "The History of England." Sir T. W. Holderness gives us a deep-sighted and masterly summary of conditions in India to-day, and of the geographical, political and religious factors of which these conditions are the product. A more interesting subject can scarcely be imagined. The antiquity of India's civilization, the maturity of her philosophy, the cruelty of her customs, the peculiarities and contradictions of her religion—all serve to give her a complex and mystical national character which has made British regulation so intricate a problem that even the partial success attained must stand as one of the modern wonders of the world. Both these volumes belong to the "Home University Library," a meritorious series of publications with which it is sought to comprehensively cover the whole field of modern knowledge.

German Varnish Making. By Prof. Max Bottler. Authorized Translation. With Notes on American Varnish and Paint Manufacture by Alvah Horton Sabin, M.S. New York: John Wiley & Sons, 1912. 12mo.; 363 pp.; 55 figures. Price, $3.50 net.

The absence of any recent work in English dealing with the progress of varnish manufacture in Germany makes the work in hand [illegible] to American and English varnish-make[illegible] descriptive list of the raw materials, the making of lacquers and varnishes is given a general explanation; the various furnaces, kettles and apparatus are described; and concise directions are given for the preparation of different varnishes from turpentine, benzine, asphaltum, caoutchouc, and alcohol. Exact formulas are listed for use on leather, on engravings, on metal, for photographic purposes, bookbinding, etc. There are also valuable formulas for composite inks. The last half of the volume is devoted to American practice, and here the translator's remarks are supplementary to his earlier volume, "Technology of Paint and Varnish." The old Crockett formulas are published, for the first time, in an appendix; though now obsolete, these are of great interest from an historic point of view, for all modern American practice is based on Crockett's work.

The School. An Introduction to the Study of Education. By J. J. Findlay, M.A., Ph.D. New York: Henry Holt & Co., 1912. 16mo.; 256 pp. Price, 50 cents net; postage, 6 cents.

Since Spencer's "Education" was published, half a century ago, conditions have greatly altered. His views still stand as convincingly common-sense and basic; but new elements have entered into the problem. With the highly specialized knowledge of the day, the dependency of the child upon the parent must often be prolonged to close upon thirty years. This, while benefiting the few that by turn of mind and strength of character are fitted for the higher professions, serves only to inculcate habits of laziness and helplessness in those of an inferior natural endowment and laxer moral makeup. Prof. Findlay not only discusses such problems very thoroughly, but also seeks to weld the whole exposition of pedagogy into one body of thought, thus aiding at the same time parent, student, and teacher. It is almost too ambitious a program for successful achievement within the limits of so small a volume, yet the result is a noteworthy and helpful addition to the literature of education.

Landmarks in French Literature. By G. L. Strachey. New York: Henry Holt & Co., 1912. 16mo.; 256 pp. Price, 50 cents net; postage, 6 cents.

The seven chapters of the brief work deal with the beginnings of French literature in the middle ages, with the renaissance, the transitional period, the age of Louis XIV, the eighteenth century, the romantic movement, and the age of criticism. As a primer of the subject it is well adapted to ground the student in a general understanding of the foundations on which French literature rests, and it is sufficiently readable to lead him to seek further information and detail. Notable personages of the pen are happily characterized, and are presented to the reader in as fair and just a light as is possible in so condensed a treatment. Their strengths and their failings are sanely contrasted, and their influences thoughtfully appraised. The volume comes in the Home University Library of Modern Knowledge.

Applied Methods of Scientific Management. By Frederic A. Parkhurst, M.E. New York: John Wiley & Sons, 1912. 8vo.; 325 pp.; illustrated. Price, $2 net.

A helpful contribution to the growing literature of scientific management will be found in Mr. Parkhurst's volume, which is an amplification of an article bearing the same title, which appeared in 1911 in *Industrial Engineering*. The work recognizes the importance of keeping mutual interests in mind, and of studying with the greatest care the psychological factors of the problem. In order to make the exposition of principles as practical and definite as possible, their working is shown in the actual example of the Ferracute Machine Company, from preliminary investigation and organization, through the establishment of every department upon a scientific basis of management and operation, to the development of time studies and the inauguration of piece-work, premium bonus, differential piece-work, and differential bonus systems of payment. The final chapter furnishes a concrete example of the course taken by an order, from initial inquiry to shipment complete, and a comparison of results under old and new methods. An appendix gives shop rules, instruction cards, follow-up methods, and time-keeping systems, with folding inserts of order forms, work schedules, route sheets, cost sheets, and final job-records.

The First Book of Photography. A Primer of Theory and Practice for the Beginner. By C. H. Claudy. 115 pp.; Illustrated. New York: McBride, Nast & Co., 1912. Price, 75 cents net.

Mr. Claudy is qualified to write this book, first, because he is an experienced newspaper and magazine photographer, and, secondly, an excellent writer of magazine articles. As might be expected, he has produced a book which is a lucid explanation of the first principles of photography from a man who knows how to present them.

A Manual of Mental Science. By Leander Edmund Whipple. New York: The Metaphysical Publishing Company, 1911. 221 pp. Price, $1.

How to Play the "Naval War Game." With a Complete Set of the Latest Rules, Full Instructions, and Some Examples of "Wars" that have actually been played. Interleaved for additional rules, notes, etc. By Fred T. Jane, Inventor of the Game, author of "Fighting Ships," Etc. Official Rules, 1912, Canceling all Others. London: Sampson Low, Marston & Co., Ltd.

The Naval War Game, which was devised some thirteen years ago by Fred T. Jane, the authority of all the world's fighting ships, has the following precise objects:

1. To afford a means of working out any strategical problems or theories with realism and excitement substituted for the "dry bones," and the consequent tactical problems automatically provided. The advantage of interest with young officers is obvious.

2. To allow the working out of any particular tactical theories under conditions as nearly as possible resembling real war in miniature.

3. To teach in the easiest and most interesting manner the guns, armor, capabilities, etc., of all warships.

The game has been played during the past decade by naval officers who have found therein a simulation of the conditions of actual naval warfare, which has enabled them to practise in the quiet of the wardroom the principles of naval strategy and tactics. The work opens with a chapter of instructions for beginners. Then follows chapters on the Players, Moving, Signaling, Battle Procedure, General Matters, under which are included an Attack and Defense of Commerce, Forts and Military Operations; the work ending with a chapter on Wars.

It should be noted that the book is interleaved throughout with blank pages for the addition of extra rules, etc.

Laboratory Problems in Physics. By Franklin T. Jones and Robert R. Tatnall. New York: The Macmillan Company, 1912. 16mo.; 81 pp.; illustrated. Price, 50 cents net.

This textbook, a revision of Crew and Tatnall's "Laboratory Manual of Physics," is intended for use in conjunction with Crew and Jones's "Elements of Physics." It places results above methods, develops the reasoning power by means of leading questions, and initiates the student into the use of very simple apparatus. The questions at the close of each exercise aim to discover to the learner the practical importance of the principles utilized, and the review method of clinching the lessons is liberally used.

Suspension Bridges and Cantilevers, Their Economic Proportions and Limiting Spans. By D. B. Steinman, Ph.D. New York: Van Nostrand Company, 1911. 16mo.; 185 pp. Price, 50 cents.

The author has made a sustained investigation with the view of determining the length of span at which the suspension bridge becomes superior to the cantilever, and the conclusions arrived at are embodied in this little treatise. Subsidiary determinations are the economic rise-ratio for suspension bridges, the minimum depth of stiffening trusses for the necessary rigidity and their economic depth, the best span-ratios and the minimum width for cantilevers. All these solutions and much other matter bearing upon bridge design may be found in the treatise.

TABLE OF CONTENTS